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CONSTRUCTIONAL ENGINEERING

INCLUDING PRESTRESSED CONCRETE

JULY 1961 **VOL. LVI. NO. 7**

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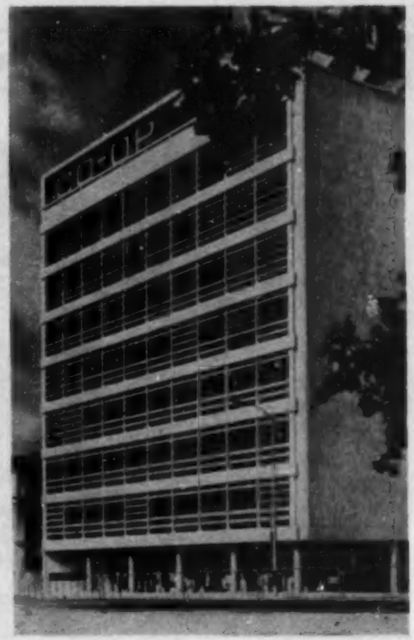
INDEX OF ADVERTISERS

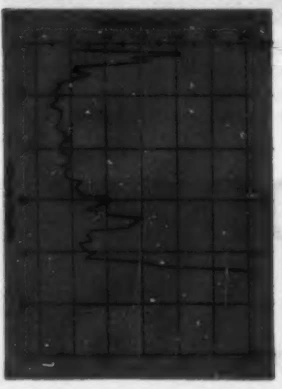
facts

THE CO-OPERATIVE BANK AND OFFICE BUILDING ON THE MARINA LAGOS · NIGERIA



STRATA

Three penetration tests were taken with the Dutch Penetrometer, of which No. 2 is reproduced below. It will be observed that this shows a pressure of 80 kgs per square cm at a depth of 30 feet, at which level the piles were based.



PROBLEM

A firm foundation for an important new building was required on the attractive Marina at Lagos. The ground at levels where ordinary foundations would normally be made was of strength inadequate for the loadings. Moreover, the ground water level was within a few feet of the surface.

SOLUTION

Trial penetration tests with the full size machine were taken, and these provided general confirmation of the penetrometer findings, and showed that piles could be formed satisfactorily at the economic depth of 31 feet to carry working loads of 50 tons.

Contract No.: BWA/L.3 · **Client:** The Co-operative Bank Limited
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Engineers: Messrs. Ove Arup & Partners · **General Contractors:** Cappa & d' Alberto Ltd.
Type of Structure: Eight-storey Bank & Office Building · **Number & Type of Piles:** 66 Franki Driven piles
Working Load: 50 tons · **Average Length:** 31′ 0″

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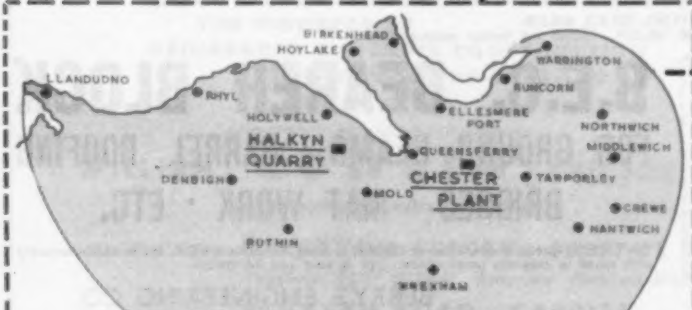
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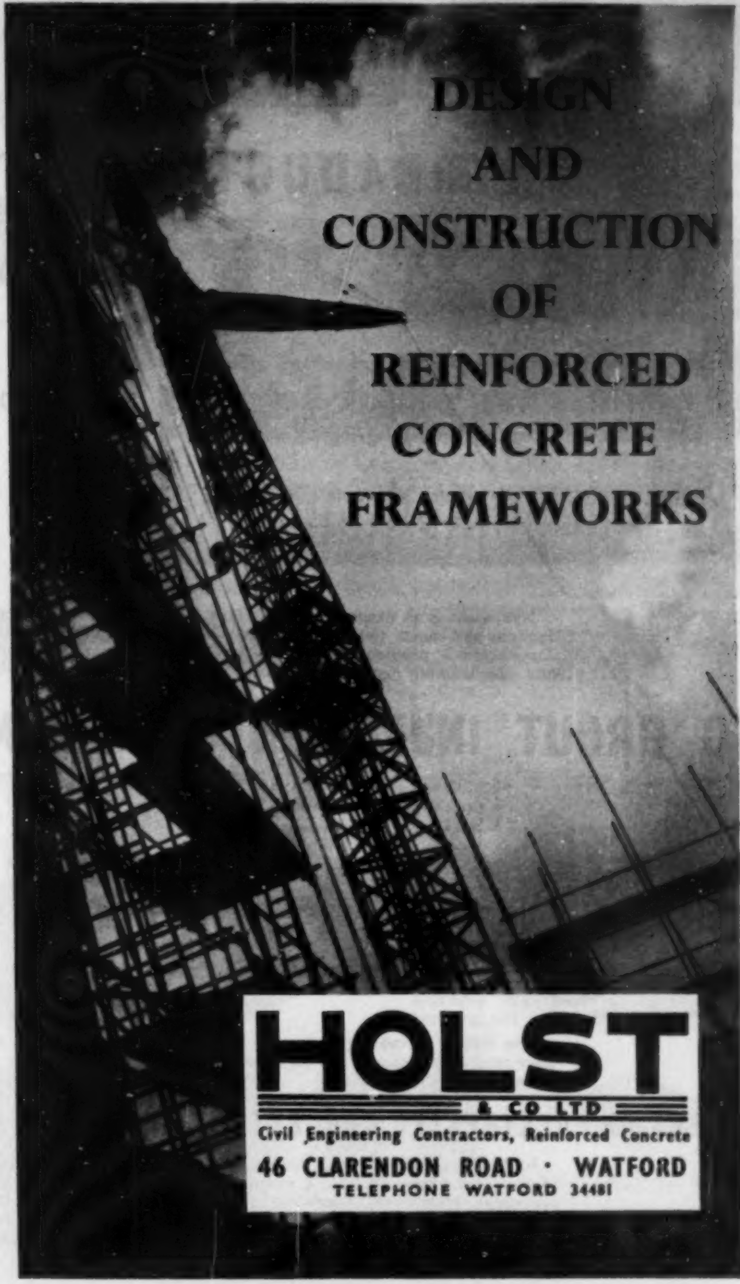
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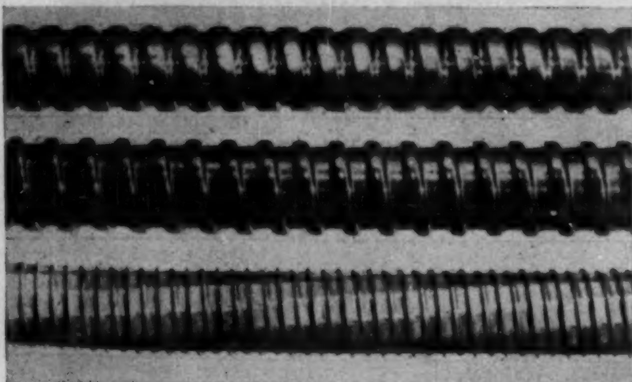

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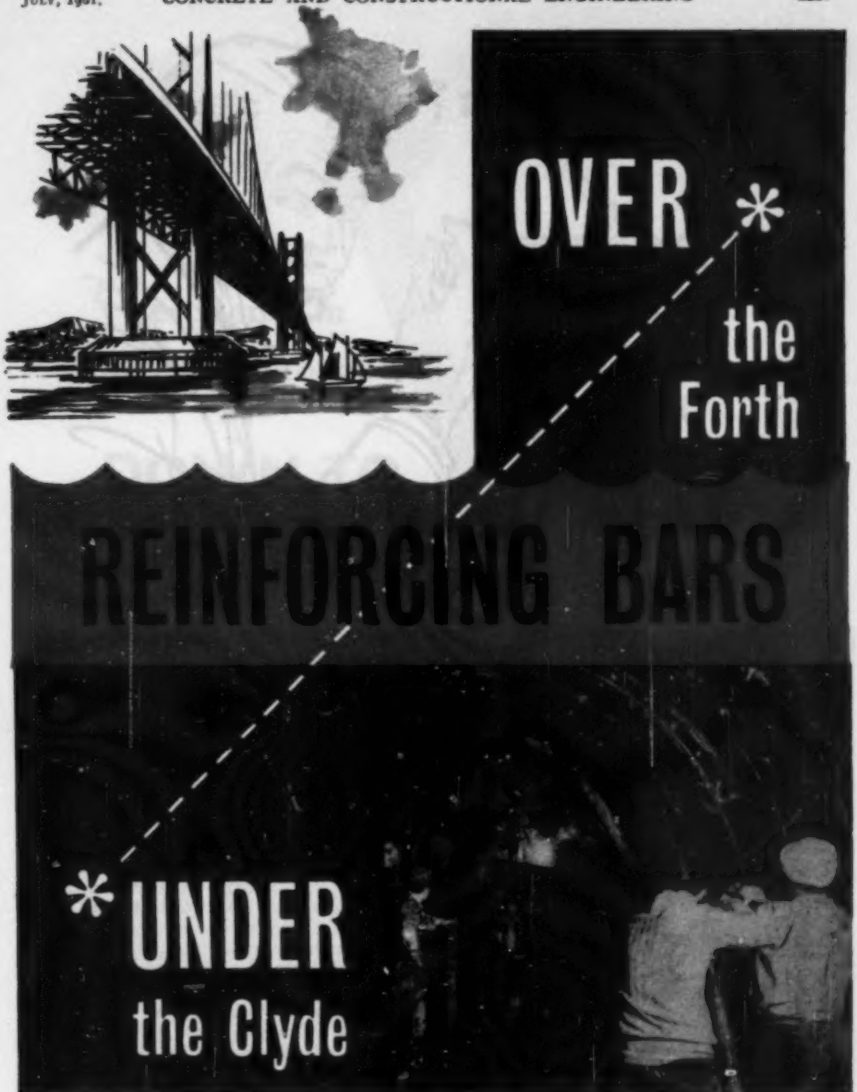
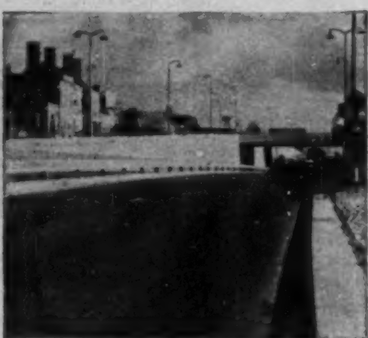


C

Waterstops?



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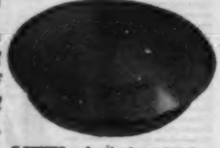

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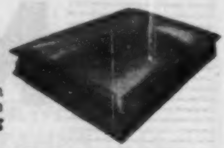

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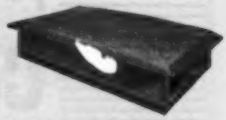

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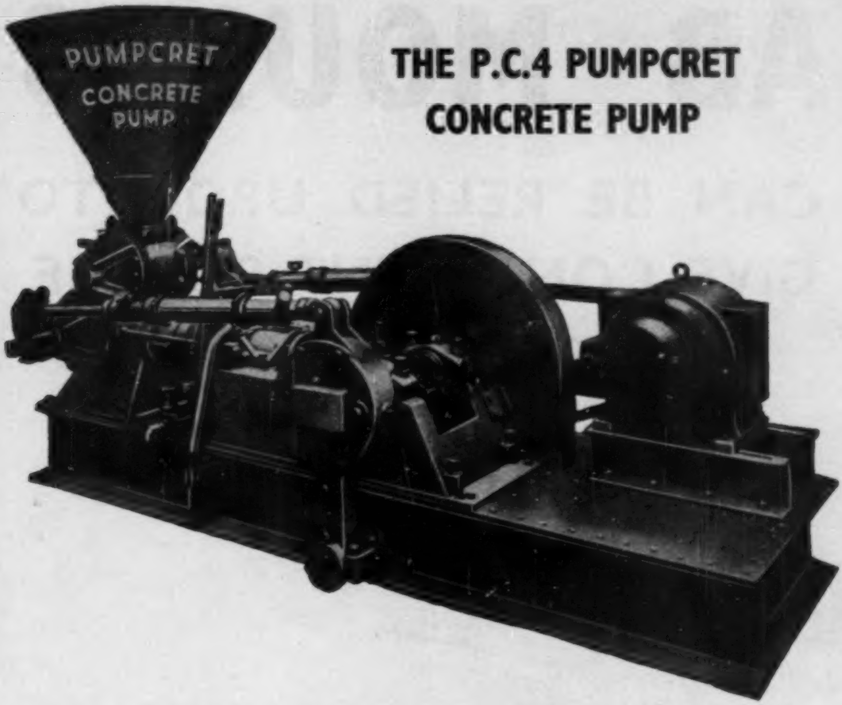

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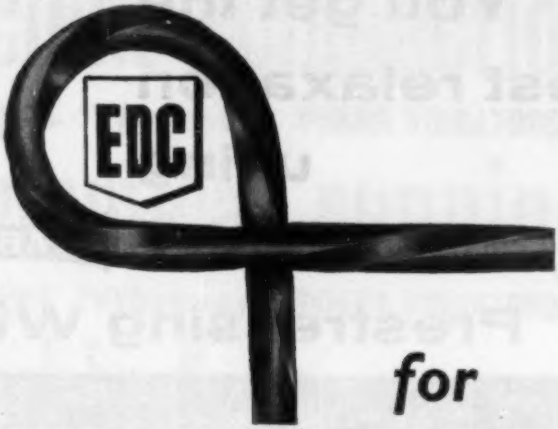

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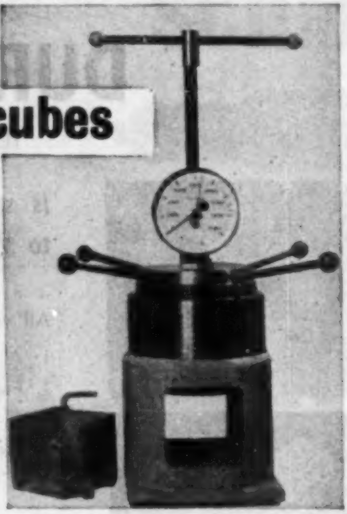

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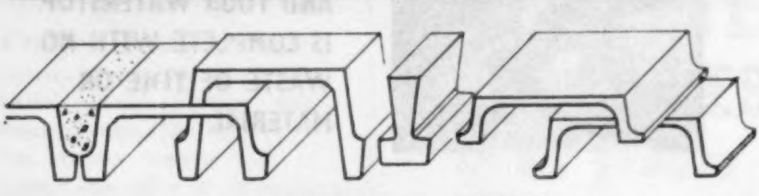

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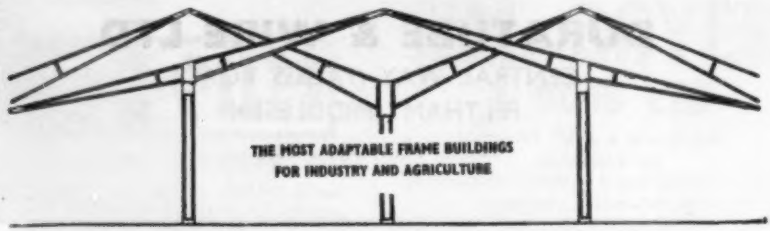

SINGLE SPAN · MULTI SPAN · CANTILEVER

The first building to be erected in the S.E. corner of the Gatwick Airport which has been developed as a maintenance area, is a 282 ft long, 112 ft wide and 41 ft high hangar for Transair Limited. The hangar is remarkable for its roof structure; notably the inter-connected 110 ft triangular precast and prestressed space frames which span the width of the building. At the front of the building, over the hangar doors, a 10 ft deep main beam was formed by fitting additional members between the ends of the secondary beams. The beam is continuous and supported by three prestressed concrete columns to provide two clear spans of 140 ft. The columns were prestressed on the Freyssinet system to support bending moments due to horizontal wind forces. The major prestressed force for the main beam was applied on the Freyssinet system. A leaflet giving comprehensive details of the complete project is available on request.

Hangar Construction at Gatwick

Sponsor: Transair Ltd.
Architects: Clive Pascall and Peter Watson.
Design and erection of structural frames: The London Ferro-Concrete Company Limited in association with A. J. and J. D. Harris.
Consulting engineers for the prestressed concrete apron: A. J. and J. D. Harris.
General Contractors for building and apron: Sir Alfred McAlpine and Son Limited.

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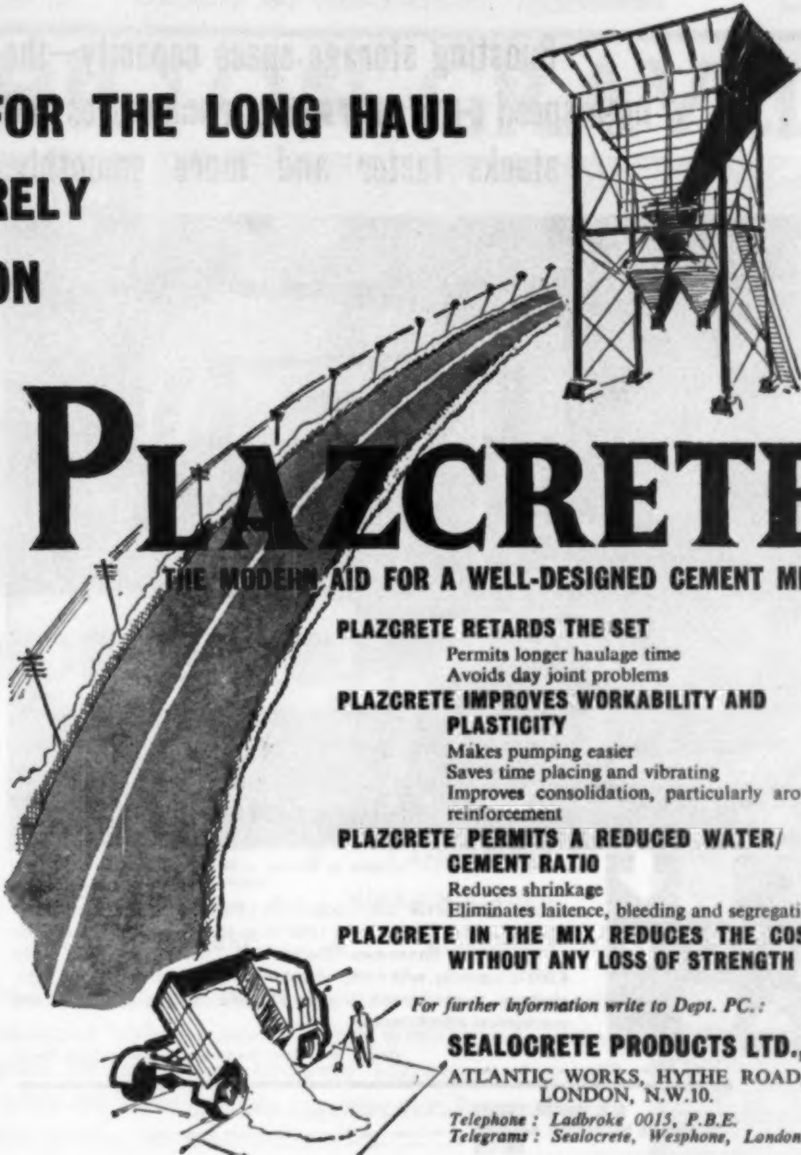

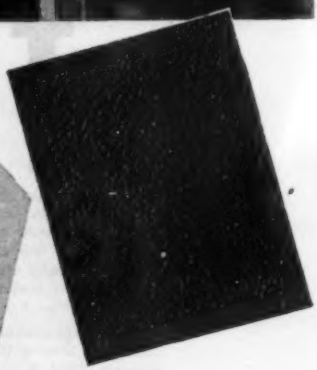

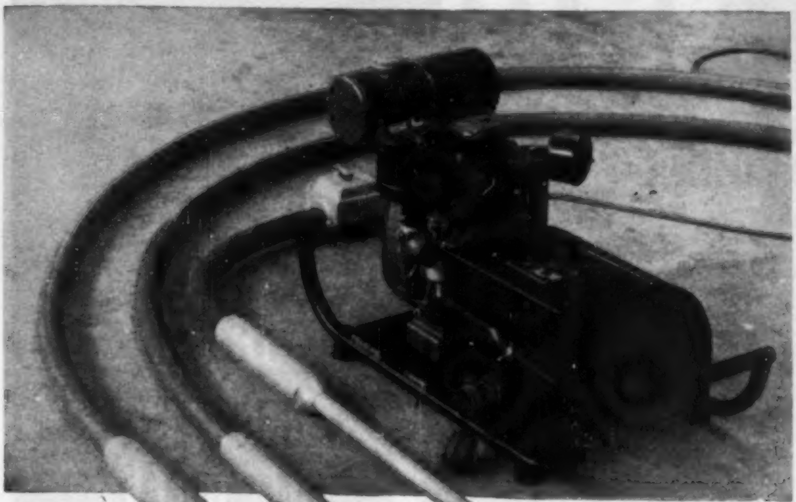

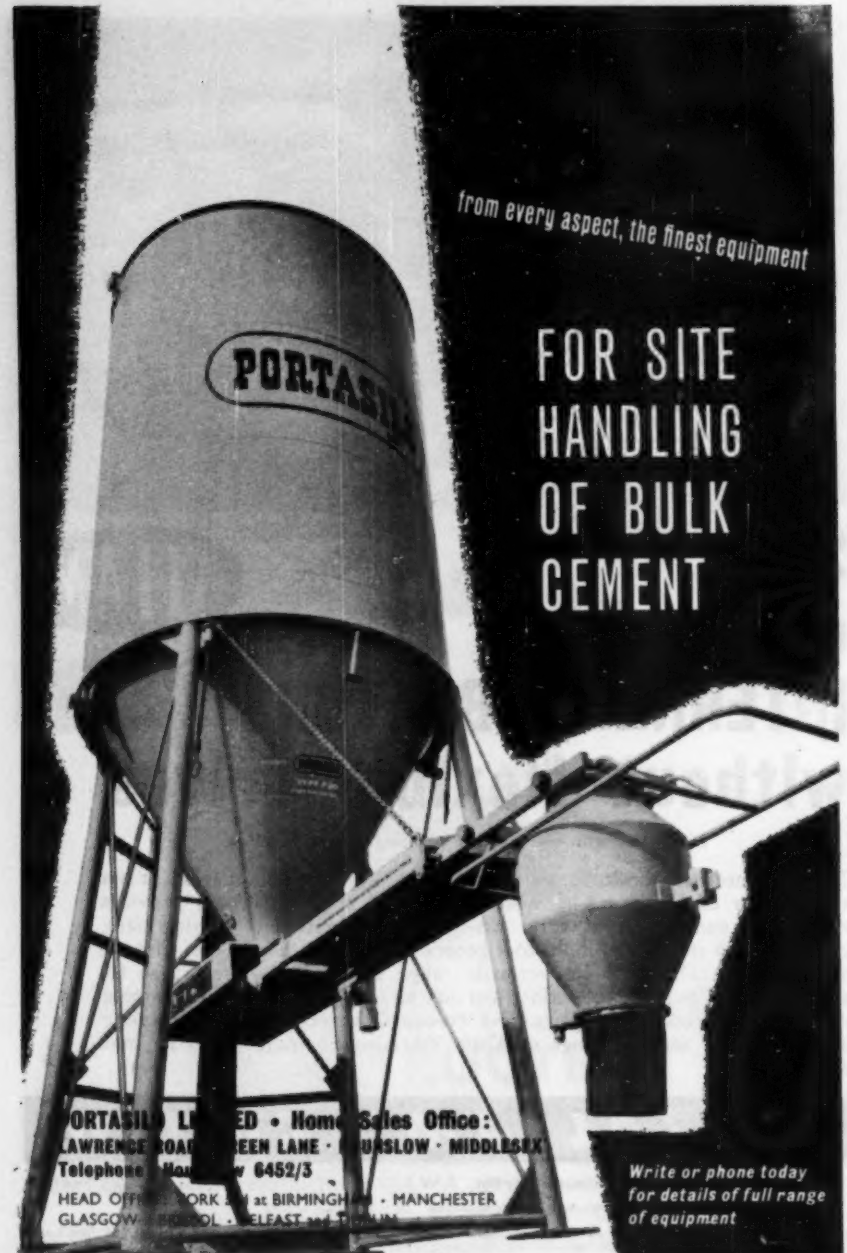
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Volume LVI, No. 7. LONDON, JULY, 1961.

EDITORIAL NOTES

Structural Safety.

BRITISH Standards are too severe. Dams burst and cranes collapse. These are some of the contrary opinions expressed at a recent conference(1) on standard specifications. The view that the requirements of some British Standards, which in other quarters have been referred to as standards of mediocrity, could well be made less stringent raises the whole question of factors of safety. In this connection the extract from an introductory note in a new book(2) on foundations, which is given in the following, is apposite.

" In theory the factor of safety is the ' strength ' of the structure divided by the loading. Since both these values in practice are stochastic (3) the result can only be statistically assessed within some arbitrary parameter. What is often miscalled the ' factor of safety ' is the ratio between the ' strength ' as calculated by one arbitrary Code of Practice and the loading stipulated by another arbitrary Code. Since these Codes vary from one edition to another and since there is no statutory guarantee that their compilers know what they are codifying, this ratio is variable and no more reliable than the opinions of those members of the drafting committee who were not too busy to take an active part in the drafting. Any interpretation must depend eventually on personal interpretation of what is ' reasonable risk ' which involves a consideration of the results of structural failure. To suggest that the lead in a pencil should be heavily reinforced to eliminate breakage is ridiculous since the consequential damage is infinitesimal. If the draughtsman was severely injured every time his pencil point broke it would be quite a different matter. Was it reasonable to suppose that the Dutch and English coast defence works that had stood for a century were ' reasonably ' safe the day before they were overtopped in 1953 ? We now know that the dam near Fréjus (or its foundations) had a factor of safety of less than unity. How many experts were satisfied that it was ' reasonably ' safe a week before failure occurred ? It is clear that any structure whose failure must involve wholesale

(1).—Seventh Standards Engineers' Conference held in London, May 1961.
(2).—" Design and Construction of Foundations." By G. P. Manning, M.Eng., M.I.C.E.
(3).—" Stochastic " = pertaining to conjecture (O.E.D.); but now used in statistics to indicate some degree of randomness.

loss of life should have a larger factor of safety than one whose failure involves only petty annoyance, but what limits should we set ? If we can increase the calculated factor of safety by 50 per cent. at a cost of only 5 per cent. increase in expenditure the decision may be easy, but if the cost increases 75 per cent. it may be difficult. In doubtful cases the engineer should estimate what an increase in the strength of the foundations would cost and how this would compare with the total final cost of the whole building since failure of a foundation involves everything above it.

Between the years 1909 and 1959, the allowable stress in mild steel in the London area has increased from 7½ to 10 tons per square inch (and now presumably to 10½ tons) while the assumed imposed load on an office floor has decreased from 100 to 50 lb. per square foot, representing a mental readjustment of 180 per cent. Is a factor of safety then, to the official mind, only a matter of opinion ? If a bearing pressure of 2 tons per square foot was considered reasonably safe on a certain type of ground in 1909 under an office building assumed to carry an imposed load of 100 lb. per square foot, should we limit the pressure to 1·5 tons per square foot if we now calculate for loads of only 50 lb. per square foot ?

If the mechanical engineer estimates that his plant will weigh 50 tons, he may, if naturally timid or doubtful of the structural engineer's ability, increase this weight to 75 tons or even 100 tons. If the engineer for the superstructure mistrusts both the mechanical engineer and the foundation engineer he may pass this on as 150 tons. If the foundation engineer also has his doubts he may design the foundations to carry 200 tons. If the mechanical engineer's estimate of 50 tons is correct and if the foundation engineer correctly assesses the allowable bearing pressure we have a factor of safety of about ten.

The only factual step towards establishing a value for the factor of safety is to test-load the finished structure. After that we still, in most cases, do not know what maximum load the structure may reasonably have to carry during its effective life (after having, of course, determined how long its effective life can reasonably be expected to last). Would it now be reasonable to include in our estimated loading the risk of the superstructure being struck by an artificial satellite ?

The disaster at Fréjus presents also the other side of the argument. Apparently the Roman amphitheatre withstood the onrush of water while modern buildings collapsed. Apart from emphasising the superb technique of the Roman engineer, was the designer of this building grossly extravagant in providing a structure that outlasted its useful life by 1500 years ? He could scarcely have foreseen that it would prove a source of attraction to tourists two thousand years after his death."

The causes and prevention of structural failures was the subject of a paper entitled " The Pathology of Construction " presented last month by M. Albert Brenier at a joint meeting of the Institution of Structural Engineers and the British Section of the Société des Ingénieurs Civils de France. The theme of the paper was that it is better to build soundly thereby avoiding damage than to have to seek remedies which are often no more than palliatives to incurable ills. This was the basic idea behind the creation in 1929 of the Bureau Securitas of the French department of public works, the mission of which was to prepare regulations principally for structural calculations and to supervise construction. The

regulations have been revised from time to time, the latest regulations for reinforced concrete being issued in 1960. Similar codes for prestressed concrete are being prepared. Supervision to prevent failures, however, constitutes the basic activity of the Bureau, and an offshoot, the Société de Contrôle Technique et d'expertise de la Construction, has been established. The means taken for the prevention of failures has enabled architects, engineers and contractors to insure against the consequences of their responsibilities. In France, this responsibility is heavy since the Civil Code, which dates from Napoleonic days, requires the guarantee of structures against the ruin of part or the whole of a structure for a period of ten years. The notion of ruin has been extended considerably by the courts to include lesser defects short of collapse.

From the numerous investigations made by the Bureau and its successors an extensive documentation has been compiled and leaflets relating to instructive cases of failure are published. The technical examination of failures of foundations or superstructures is of great importance since failures are true full-scale tests to destruction.

Ready-mixed Concrete.

THE popularity of ready-mixed concrete is growing considerably. Its use is today by no means confined to building sites in cities where in this country, for at least three decades, it has been acknowledged as a convenient form of supply, mainly because it is necessary for one vehicle, that is the mobile agitator or mixer, to traverse the streets instead of several vehicles delivering aggregates and cement. Before World War II, there were barely half-a-dozen firms supplying ready-mixed concrete, but in 1961 there are upwards of one hundred and thirty. In 1951, the seven members of the British Ready Mixed Concrete Association produced about 187,000 cu. yd., but in 1960 the membership of the Association had increased to about eighty and their output had increased to nearly five million cubic yards.

On extensive works such as roads and motorways, it is not uncommon for the concrete to be batched or mixed at a central point and distributed in mobile mixers or agitators. However, in districts remote from cities or sites of large works, many ready-mixed concrete plants have been installed, generally near aggregate pits or quarries, from which concrete is supplied to large and small constructional works in the neighbourhood. Some of the plants, such as those newly installed plants described elsewhere in this number, are highly mechanised. Others, such as one at Fulham (see this journal for October 1960) which produces up to 1500 cu. yd. daily, have high productive capacities. What is probably the world's record output is that of a plant in Montreal, Canada, which, as reported at the annual convention of the National Ready Mixed Concrete Association (U.S.A.) held at Miami Beach in January last, has a capacity of 300 cu. yd. per hour.

Parallel to the growth of the use of ready-mixed concrete in Great Britain is the corresponding development of mobile mixers, and some new vehicles of this type are described on page 263 of this number.

Book Reviews.

"Prestressed Concrete Simply Explained." By H. Kaylor. (London: Contractor's Record Ltd. 1961. 28*s*.)

THE implication in the title of this small book is well maintained in the clearly written text which is based mainly on the two current British Standard codes of practice dealing with prestressed concrete. There is, however, much material additional to, or in amplification of, the codes. Some, but by no means all, of the systems of prestressing available in this country are described. Some of the examples give solutions of a problem by the adoption of two or more systems. Another feature of the descriptive numerical examples is that in many cases any formulæ used are repeated in the example with an explanation of the symbols. More consideration could be given to the design of the ends of beams; but the solitary reference to this subject in the index does not do justice to the few references in the text.

Since the volume is evidently meant as a book for beginners, it may seem out of place to include general illustrations of extraordinary structures such as the water tower at Örebro and the exhibition hall in Paris; detailed descriptions with drawings of more usual simple works would be advantageous.

"The Geometric Design of Modern Highways." By J. H. Jones. (London: E. & F. N. Spon Ltd. 1961. 63*s*.)

THE claim that this book is an attempt to interpret American and Continental practice in highway engineering in terms of the special requirements of Britain's programme of road construction is well based except that the author has not troubled in all cases to translate American terms into their English equivalents. Much of the subject matter is no doubt in the province of that new breed of practitioners, namely, traffic engineers, as is seen from the contents which include the principles of highway design, horizontal and vertical alignment, cross-section of roads, sign-posts, markings on carriageways, junctions, separation of carriageways, and the analysis of the designs of existing roads. There is nothing on the actual construction of roads.

"Papers Presented at the Third International Congress of the Precast Concrete Industry." Stockholm, 1960. (London: Distributed on behalf of the British Cast Concrete Federation by Concrete Publications Ltd. 1961. Main Papers and Reports £3 3*s*. post free; in Canada and U.S.A. 15 dollars. Main Papers and Reports with Supplementary Papers and Reports £4 4*s*. post free; in Canada and U.S.A. 20 dollars.)

THE papers and reports presented at the Third International Congress of the Precast Concrete Industry, held in Stockholm in 1960, are collated in this publication, which is in the English language and in loose-leaf form in a substantial binder. The publication is in two editions, one containing the reports and main papers only and the other the reports and main papers together with supplementary papers and reports.

Although the subject-matter is primarily of interest to the precast concrete industry, many of the papers such as those dealing with vibration, shrinkage and structural precast concrete are of value to other branches of concrete engineering. The contents also include papers dealing with concrete pipes, and in particular the protection of pipes against aggressive soils and waters, plastic coverings and ocrate methods. Psychosociological problems associated with human relations in the products industry are also considered. The subjects of the supplementary papers and reports include precast concrete shells, bridge construction, flues, beams with high-strength reinforcement, electrical curing, and the concrete block industry.

Books Received.

"Constructional Engineer." By E. Leyland. [London: Edmund Ward (Publishers) Ltd. 1961. Price 9*s*. 6*d*.]

"Graphic Statics." By C. S. Benson. (London: B. T. Batsford Ltd. 1961. Price 25*s*.)

"Industrial Architecture." By J. F. Munce. (London: Iliffe Books Ltd. 1961. Price £5 5*s*.)

"Motopia." By G. A. Jellicoe. (London: Studio Books, Longacre Press Ltd. 1961. Price 42*s*.)

"The Business of Management." By R. Falk. (London: Penguin Books Ltd. 1961. Price 3*s*. 6*d*.)

Balcony Slabs Spanning in Two Directions.

By L. S. MÜLLER.

THE accompanying tables apply to the design of two common cases of balcony slabs, namely, rectangular panels fixed on three sides and unsupported on the fourth, and rectangular panels with two adjacent sides fixed and the other two sides unsupported. The tables are based on the yield-line method.

Rectangular Panel Fixed on Three Sides and Unsupported on one Side.

CASE I.—$z \leq L_x$: yield-line pattern and notation as in *Diagram* I, *Table* I. Also q = total load, n = factor of safety required, and $q_{cr} = nq$ = critical load.

The virtual external work of the load in the stage when the yield-lines develop may be expressed as follows.

$$U_e = \left[\frac{L_y z}{2 \times 3} + \frac{2L_y z}{2 \times 2 \times 3} + \frac{2(L_x - z)L_y}{2 \times 2}\right] q_{cr} = \frac{L_y q_{cr}}{6}(3L_x - z). \quad (1)$$

If m_x, m_y are the bending moments per unit length in the span, m_x', m_y' the support bending moments along yield-lines in the directions x and y, the virtual internal work of the yield-moments is

$$U_i = \frac{4L_x}{L_y}(m_y + m_y') + \frac{L_y}{z}(m_x + m_x').$$

Assuming arbitrarily that $m_x = m_y$ and $m_x' = m_y' = 2m_y$,

$$U_i = \left(\frac{12L_x}{L_y} + \frac{3L_y}{z}\right) m_y. \quad (2)$$

Equating (1) and (2) $U_e = U_i$, from which

$$q_{cr} = \frac{6}{L_y^2} \cdot \frac{12L_x z + 3L_y^2}{3L_x z - z^2} m_y. \quad (3)$$

The critical load is when this is a minimum, that is when $\frac{dq_{cr}}{dz} = 0$, and for this condition $4L_x z^2 + 2L_y^2 z - 3L_x L_y^2 = 0$. Solving for z, and denoting $\frac{L_y}{L_x} = \lambda$,

$$z = \frac{\sqrt{12 + \lambda^2} - \lambda}{4} L_y = \beta L_y. \quad (4)$$

The boundary of validity is when $z \leq L_x$, which gives a maximum value of λ equal to 2. Substituting in (3), $z = \beta L_y$, and solving for m_y gives

$$m_y = \left[\frac{\lambda^2 \beta(3 - \lambda\beta)}{12\beta + 3\lambda}\right]\left(\frac{q_{cr} L_x^2}{6}\right) = \gamma\, q_{cr}\, L_x^2. \quad (5)$$

CASE II.—$2z \leq L_y$: yield-line pattern as in *Diagram* II, *Table* I. The virtual external work of the load is

$$U_e = \frac{L_x q_{cr}}{6}(3L_y - 2z). \quad (6)$$

The virtual internal work of the yield-moments is

$$U_i = \frac{2m_y' L_x}{z} + \frac{2m_x' z}{L_x} + \frac{m_x'(L_y - 2z)}{L_x} + \frac{2m_x z}{L_x} + \frac{2m_y L_x}{z}.$$

With $m_x = m_y$, and $m_x' = m_y' = 2m_y$

$$U_i = \left[\frac{6L_x}{z} + \frac{2(L_y + z)}{L_x}\right] m_y. \quad (7)$$

Equating (6) and (7) and solving for q_{cr} gives

$$q_{cr} = \frac{12}{L_x^2} \cdot \frac{3L_x^2 + L_y z + z^2}{3L_y z - 2z^2} m_y. \quad (8)$$

TABLE I.—RECTANGULAR PANEL SUPPORTED ON THREE SIDES.

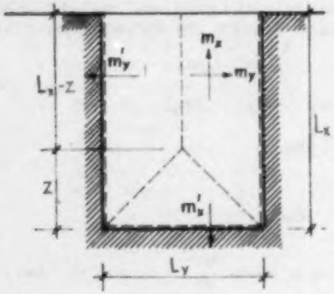
$m_x = m_y$; $m'_x = m'_y = 2\,m_y$

I. $\frac{L_y}{L_x} \leq 2.00$

$Z \leq L_x$

$Z = \beta L_y$

$m_y = \gamma\, q_{cr} L_x^2$



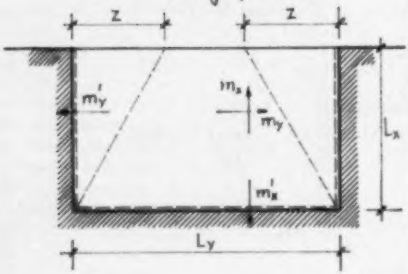
L_y/L_x	β	γ
0.3	0.7950	0.00316
0.4	0.7705	0.00529
0.5	0.7500	0.00781
0.6	0.7280	0.01063
0.7	0.7080	0.01367
0.8	0.6900	0.01687
0.9	0.6700	0.02019
1.0	0.6510	0.02357
1.1	0.6345	0.02699
1.2	0.6160	0.03040
1.3	0.6000	0.03380
1.4	0.5845	0.03714
1.5	0.5690	0.04044
1.55	0.5612	0.04204
1.6	0.5540	0.04365
1.7	0.5400	0.04676
1.8	0.5265	0.04979
1.9	0.5110	0.05273
2.0	0.5000	0.05556

II. $\frac{L_y}{L_x} \geq 1.55$

$Z \leq \frac{L_y}{2}$

$Z = \beta L_x$

$m_y = \gamma\, q_{cr} L_x^2$



L_y/L_x	β	γ
1.55	0.7748	0.04169
1.6	0.7869	0.04337
1.7	0.8101	0.04667
1.8	0.8315	0.04991
1.9	0.8513	0.05309
2.0	0.8695	0.05619
2.1	0.8869	0.05922
2.2	0.9029	0.06218
2.3	0.9178	0.06506
2.4	0.9318	0.06788
2.5	0.9449	0.07063
2.6	0.9573	0.07330
2.7	0.9688	0.07591
2.8	0.9798	0.07845
2.9	0.9902	0.08092
3.0	1.0000	0.08333

From $\dfrac{dq_{cr}}{dz} = 0$, $$z = \frac{6L_x}{5\lambda}(\sqrt{1 + 1{\cdot}25\lambda^2} - 1) = \beta L_x. \quad . \quad . \quad . \quad (9)$$
The boundary of validity is when $2z = L_y$, which gives a minimum value of λ equal to $1{\cdot}55$. Substituting $z = \beta L_x$ in equation (8), and solving for m_y gives

$$m_y = \frac{3\lambda\beta - 2\beta^2}{3 + \lambda\beta + \beta^2}\cdot\frac{q_{cr}L_x^2}{12} = \gamma q_{cr}L_x^2. \quad . \quad . \quad . \quad . \quad (10)$$

Obviously there is an overlap between the two cases between $\lambda = 1{\cdot}55$ and $\lambda = 2{\cdot}0$ since the equations of virtual work have been determined for different conditions. What is interesting is that for the factors γ within the region of the overlap almost identical values are obtained when computed from either of the yield-line patterns. The values of β and γ for both cases are tabulated as functions of λ in *Table* I. The greater value of m_y should be adopted.

Rectangular Panel with Two Adjacent Sides Fixed, and the other Sides Unsupported.

Referring to the diagram in *Table* II, it can be proved that for any value of λ the yield-line denoted by a—a will give a higher value for the critical load than the other pattern shown on the same diagram. Notwithstanding, the slab must be reinforced for the possible yield-line a—a and for the corresponding load as well, otherwise the slab may fail along yield-line a—a before the decisive pattern has developed.

The virtual external work of the load for the decisive pattern may be expressed as follows.

$$U_e = \frac{2L_xzq_{cr}}{2 \times 3} + \frac{(L_y - z)L_xq_{cr}}{2} = \frac{L_x}{2}\left(L_y - \frac{z}{3}\right)q_{cr}. \quad . \quad . \quad (11)$$

The virtual internal work of the yield-moments is

$$U_i = \frac{m_y'L_x}{z} + \frac{m_yL_x}{z} + \frac{m_xz}{L_x} + \frac{m_x'L_y}{L_x}$$
$$= \frac{L_x}{z}(m_y + m_y') + \frac{m_xz + m_x'L_y}{L_x}.$$

(*a*).—Assume arbitrarily that $m_x = m_y$ and $m_x' = m_y' = 2m_y$. Then

$$U_i = m_y\left(\frac{3L_x}{z} + \frac{z + 2L_y}{L_x}\right). \quad . \quad . \quad . \quad . \quad (12)$$

Equating (11) and (12) gives $\dfrac{L_x}{2}\left(L_y - \dfrac{z}{3}\right)q_{cr} = \left(\dfrac{3L_x}{z} + \dfrac{z + 2L_y}{L_x}\right)m_y.$

Solving for q_{cr} gives $$q_{cr} = \frac{2(3L_x^2 + 2L_yz + z^2)m_y}{L_x^2\left(zL_y - \dfrac{z^2}{3}\right)}. \quad . \quad . \quad . \quad . \quad . \quad (13)$$

For the minimum value of q_{cr}, $\dfrac{dq_{cr}}{dz} = 0$ from which

$$z = \frac{3}{5\lambda}(\sqrt{1 + 5\lambda^2} - 1)L_x = \beta L_x. \quad . \quad . \quad . \quad . \quad . \quad (14)$$

Substituting $z = \beta L_x$ in (13) and solving for m_y gives

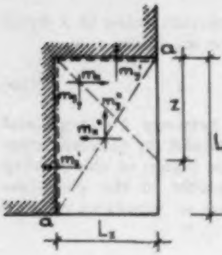
$$m_y = \frac{3\beta\lambda - \beta^2}{3 + 2\beta\lambda + \beta^2}\cdot\frac{q_{cr}L_x^2}{6} = \gamma q_{cr}L_x^2. \quad . \quad . \quad . \quad (15)$$

(*b*).—Assuming $m_x = m_y$, $m_x' = 2m_y$, and $m_y' = 3m_y$, by the same consideration as before, for the minimum value of q_{cr}

$$z = \frac{4}{5\lambda}(\sqrt{1 + 3{\cdot}75\lambda^2} - 1)L_x = \beta L_x. \quad . \quad . \quad . \quad . \quad (16)$$

and $$my = \frac{3\beta\lambda - \beta^2}{4 + 2\beta\lambda + \beta^2}\cdot\frac{q_{cr}L_x^2}{6} = \gamma q_{cr}L_x^2. \quad . \quad . \quad . \quad . \quad (17)$$

TABLE II.—RECTANGULAR PANEL SUPPORTED ON TWO ADJACENT SIDES.



$\frac{L_y}{L_x} = \lambda$

$z = \beta L_x$

$m_y = \gamma q_{cr} L_x^2$

OVER POSSIBLE YIELD-LINE a-a NEGATIVE REINFORCEMENT FROM EQUATION:

$m_x'' = m_y'' = \frac{\lambda^2}{6(\lambda^2+1)} q_{cr} L_x^2 = \delta q_{cr} L_x^2$

SHOULD BE PROVIDED.

	$m_x = m_y$, $m_x' = m_y' = 2m_y$		$m_x = m_y$, $m_x' = 2m_y$, $m_y' = 3m_y$		
L_y/L_x	β	γ	β	γ	δ
1.0	0.870	0.0562	0.944	0.0477	0.0833
1.1	0.903	0.0622	0.986	0.0532	0.0913
1.2	0.932	0.0679	1.018	0.0587	0.0984
1.3	0.957	0.0733	1.051	0.0637	0.1047
1.4	0.980	0.0785	1.079	0.0685	0.1104
1.5	1.000	0.0833	1.105	0.0733	0.1154
1.6	1.018	0.0880	1.128	0.0777	0.1199
1.7	1.034	0.0924	1.149	0.0820	0.1238
1.8	1.058	0.0966	1.166	0.0860	0.1274
1.9	1.062	0.1006	1.184	0.0900	0.1305
2.0	1.075	0.1044	1.200	0.0938	0.1333
2.1	1.086	0.1080	1.215	0.0973	0.1359
2.2	1.096	0.1114	1.227	0.1007	0.1381
2.3	1.106	0.1147	1.240	0.1040	0.1402
2.4	1.115	0.1179	1.250	0.1072	0.1420
2.5	1.123	0.1209	1.261	0.1102	0.1437
2.6	1.131	0.1237	1.271	0.1132	0.1452
2.7	1.138	0.1265	1.280	0.1160	0.1466
2.8	1.144	0.1291	1.287	0.1185	0.1478
2.9	1.151	0.1316	1.297	0.1212	0.1490
3.0	1.156	0.1341	1.305	0.1237	0.1500

As already mentioned, a—a is a possible yield-line and, although not decisive for the critical load, reinforcement must be provided for the negative yield-moments caused by it. The moment developed along a—a (*Fig.* 1) is

$$M_a = \frac{q_{cr} L_x L_y h}{2 \times 3} = \tfrac{1}{6} L_x^2 L_y \sin\phi. \quad . \quad . \quad . \quad . \quad (18)$$

From the vector-triangle, $M_a = M_x \sin\phi + M_y \cos\phi$, or

$$\tfrac{1}{6} q_{cr} L_x^2 L_y \sin\phi = m_x'' L_y \sin\phi + m_y'' L_x \cos\phi.$$

Dividing by $L_x \sin\phi$ gives $\frac{1}{6} q_{cr} L_x L_y = m_x'' \frac{L_y}{L_x} + m_y'' \cot\phi$. Substituting $\cot\phi = \frac{L_x}{L_y}$

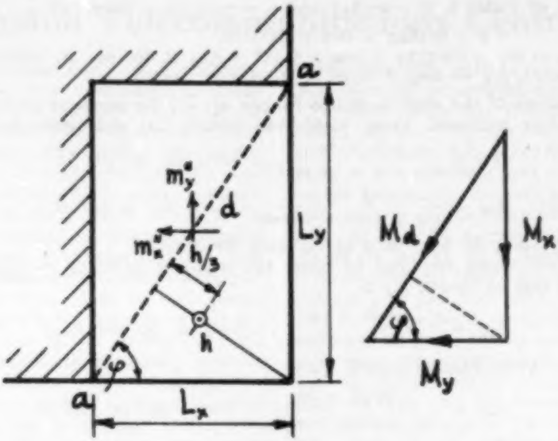


Fig. 1.

gives $$\tfrac{1}{6}q_{cr}L_xL_y = m_x''\frac{L_y}{L_x} + m_y''\frac{L_x}{L_y} = m_x''\lambda + \frac{m_y''}{\lambda}. \qquad (19)$$

Since $\dfrac{M_x}{M_y} = \tan\phi = \dfrac{m_x''L_y}{m_y''L_x}$, it follows that

$$\frac{m_x''}{m_y''} = \tan\phi\cot\phi = 1 \qquad (20)$$

that is, it is not possible to choose freely the value of $\dfrac{m_x''}{m_y''}$ since they must be equal.

From (19) therefore $\tfrac{1}{6}q_{cr}L_xL_y = m_y''\left(\lambda + \dfrac{1}{\lambda}\right)$, or, if $L_y = \lambda L_x$, $\dfrac{q_{cr}L_x^2}{6} = m_y''\left(1 + \dfrac{1}{\lambda^2}\right)$

and $$m_y'' = m_x'' = \frac{1}{6\left(1 + \dfrac{1}{\lambda^2}\right)}q_{cr}L_x^2 = \frac{\lambda^2}{6(\lambda^2+1)}q_{cr}L_x^2 = \delta q_{cr}L_x^2 \qquad (21)$$

The factors β and γ for both sub-cases (*a*) and (*b*), and the factor δ as functions of λ are tabulated in *Table* II.

Equations (18) to (21) were derived by Mr. A. Zaslavsky, Associate Professor, Technion, Haifa.

Examples.

(1) For a rectangular balcony slab fixed along three sides, and unsupported along the fourth side, L_y = 8 ft. 9 in. and L_x = 6 ft. 3 in. The load is as follows.

Assuming 4-in. slab	= 50 lb. per sq. ft.
Floor construction, plaster, etc.	= 30 „ „ „ „
Dead load	= 80 „ „ „ „
Imposed load	= 100 „ „ „ „
Total load	180 „ „ „ „

Assume $n = 2$. The critical load $q_{cr} = 2 \times 180 = 360$ lb. per sq. ft.

$$\lambda = \frac{L_y}{L_x} = \frac{105}{75} = 1{\cdot}4.$$

From Part I of *Table* I, $\beta = 0{\cdot}5845$ and $\gamma = 0{\cdot}03714$. Therefore

$$z = 0{\cdot}5845 \times 105 = 61{\cdot}3 \text{ in.}$$
$$m_y = m_x = 0{\cdot}03714 \times 360 \times 6{\cdot}25^2 = 523 \text{ ft.-lb. per ft. width.}$$
$$m_x' = m_y' = 2m_y = 1046 \text{ ft.-lb. per ft. width.}$$

If the yield-stress of the steel is 36,000 lb. per sq. in. the reinforcement to resist the positive bending moments along yield-lines within the slab with $d_x = 3$ in. and $d_y = 3\frac{1}{4}$ in. is

$$A_{sx} = \frac{523 \times 12}{0{\cdot}9 \times 3 \times 36{,}000} = 0{\cdot}065 \text{ sq. in. per ft.,}$$

and $$A_{sy} = \frac{523 \times 12}{0{\cdot}9 \times 3{\cdot}25 \times 36{,}000} = 0{\cdot}06 \text{ sq. in per ft.}$$

Therefore provide $\frac{1}{4}$-in. bars at 9 in. in both directions.

The reinforcement required to resist the negative bending moment along the support yield-line of length L_y is

$$A_{sx}' = \frac{1046 \times 12}{0{\cdot}9 \times 3 \times 36{,}000} = 0{\cdot}13 \text{ sq. in. per ft.,}$$

and along the yield-lines of length L_x is

$$A_{sy}' = \frac{1046 \times 12}{0{\cdot}9 \times 3{\cdot}25 \times 36{,}000} = 0{\cdot}12 \text{ sq. in. per ft.}$$

Therefore provide $\frac{1}{4}$-in. bars at $4\frac{1}{2}$-in. centres across each support.

(2) Consider a balcony slab of the same size as in Example (1) but fixed along two adjacent sides and unsupported along the other two sides.

Assuming $m_x = m_y$ and $m_x' = m_y' = 2m_y$ from Table II (for $\lambda = 1{\cdot}4$), $\beta = 0{\cdot}98$, $\gamma = 0{\cdot}0785$, and $\delta = 0{\cdot}1104$. Therefore

$$z = 0{\cdot}98 \times 75 \text{ in.} = 73\frac{1}{2} \text{ in.} = 6 \text{ ft. } 1\frac{1}{2} \text{ in.}$$
$$m_x = m_y = 0{\cdot}0785 \times 360 \times 6{\cdot}25^2 = 1105 \text{ ft.-lb. per ft.}$$
$$m_x' = m_y' = 2m_y = 2210 \text{ ft.-lb. per ft.}$$
$$m_x'' = m_y'' = 0{\cdot}1104 \times 360 \times 6{\cdot}25^2 = 1555 \text{ ft.-lb.}$$

The reinforcement required to resist the positive bending moment along the internal yield-line is $A_{sx} = \dfrac{1105 \times 12}{0{\cdot}9 \times 3 \times 36{,}000} = 0{\cdot}136$ sq. in. per ft.,

and $$A_{sy} = \frac{1105 \times 12}{0{\cdot}9 \times 3{\cdot}25 \times 36{,}000} = 0{\cdot}126 \text{ sq. in. per ft.}$$

Provide $\frac{1}{4}$-in. bars at 4-in. centres.

The reinforcement required to resist the negative bending moment along supports is

$$A_{sx}' = \frac{2210 \times 12}{0{\cdot}9 \times 3 \times 36{,}000} = 0{\cdot}272 \text{ sq. in. per ft.,}$$

and $$A_{sy}' = \frac{2210 \times 12}{0{\cdot}9 \times 3{\cdot}25 \times 36{,}000} = 0{\cdot}252 \text{ sq. in. per ft.}$$

Provide $\frac{3}{8}$-in. bars at $4\frac{1}{2}$-in. centres.

The reinforcement required to resist the negative bending moment along yield-line a—a is

$$A_{sx}'' = \frac{1555 \times 12}{0{\cdot}9 \times 3 \times 36{,}000} = 0{\cdot}192 \text{ sq. in. per ft.,}$$

and $$A_{sy}'' = \frac{1555 \times 12}{0{\cdot}9 \times 3{\cdot}25 \times 36{,}000} = 0{\cdot}177 \text{ sq. in. per ft.}$$

Provide $\frac{3}{8}$-in. bars at 7-in. centres.

London Telecommunications Centre.

The Fleet Building (*Fig.* 1) in Farringdon Street is the new telecommunications centre for London and has been built for the General Post Office to accommodate equipment and office staff. The building, which is of reinforced concrete construction, has fifteen floors and is approximately 165 ft. high above street level. The plan of the building, which is governed by operational requirements and the location of apparatus, is based on a module dimension of 11 ft. 5¼ in. in both directions. The site has frontages of 230 ft., 250 ft., and 230 ft. on streets on three sides; the remaining boundary adjoins existing buildings. The building is founded on firm clay at a depth of up to 50 ft. below the pavement. The basement walls (*Fig.* 2) are of semi-mass concrete, lightly reinforced, with a maximum thickness of 9 ft. Most of the retaining walls were constructed by the trench-and-dumpling method. Little water was encountered during excavation and the concrete walls in contact with the clay have no watertight membrane.

In most cases the columns are supported on the retaining walls or on the foundation raft, but bored piles are provided on the northern part of the site due to the proximity of existing buildings. The spacing of the external columns is 5 ft. 8⅝ in. In operational areas, the beams are at 5-ft. 8⅝-in. centres. Generally columns and beams are not plastered. Column and pier sizes were standardized. The lower six floors comprise solid-slabs designed to carry heavy loads from the equipment; the storey height is 14 ft. 9 in. The remaining nine floors are 10 ft. from floor to floor and of hollow clay-block construction designed for office loading. The roof is of similar construction. Where hollow-block construction is used the soffit is flush between the internal spine beam and external columns. On the northern side there are three stairs of various widths; one stair projects to serve

Fig. 1.

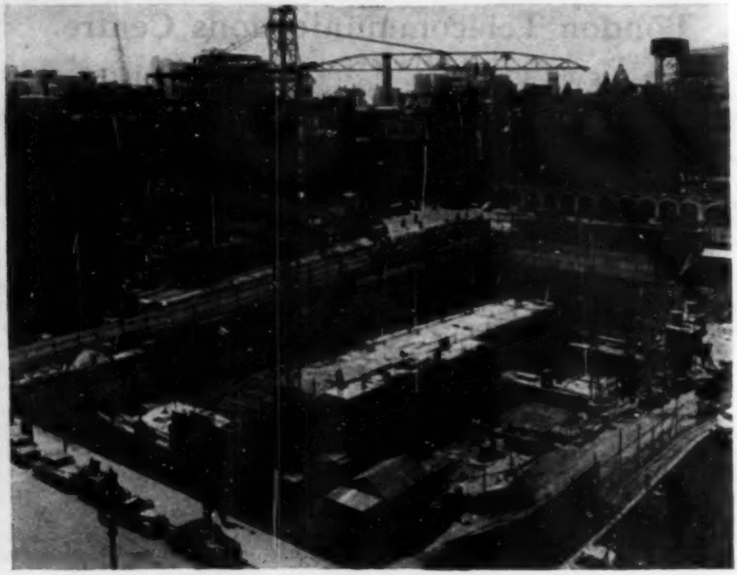


Fig. 2.

as a " stop " to the northern elevation and as a support to the adjoining party-wall.

Drainage in the ground-floor kitchen area is accommodated within a space 1 ft. 3 in. deep between the solid floor slab and the underside of the false ceiling to the basement. The space is water-tight to protect the apparatus immediately below. Plumbing and sanitary services are generally in two vertical ducts which extend throughout the height of the building. To enable the " Telex " equipment to be installed at an early date, temporary overhead protection was provided in the basement while construction of the superstructure proceeded.

The external finish is Portland stone with the exception of end flank walls, which are finished with Derbydene stone. A number of ceramic faience murals, depicting Post Office activities, have been erected to the right of the main entrance.

The building, the estimated cost of which is about £1,900,000 and which has a volume of about 6,120,000 cu. ft., was designed by the Architect's Department of the Ministry of Works. The Structural Department of the Ministry worked in conjunction with Messrs. W. V. Zinn and Associates. The general contractors were Messrs. Tersons Ltd.

Analysis of Frames with V-supports.

In *Fig.* 5 of the article entitled "Analysis of Frames with V-supports ", in the number of this journal for April 1961, the bending-moment diagrams for members 2-A and 5-B should be drawn on the other side of the member to that shown, since the diagrams are on the " tension side " of each member.

A Concrete Ship.

A 3500-ton ship, which is being built of reinforced concrete at a Baltic shipyard, will be about 280 ft. long, with a beam of 55 ft., and is due for completion this autumn. This ship, which is a refrigerated vessel, will be used for the storage of fish and the production of ice for a fishing fleet.

A Practical Comprehensive Method of Designing Reinforced Concrete Sections.—II.*

By J. RYGOL, B.Sc.(Eng.).

ELASTIC (MODULAR-RATIO) METHOD.

THE assumed triangular distributions of stresses and strains are shown in *Fig.* 7.

Basic Equations and Factors.

Basic Equations.—The basic equations (1), (2) and (3) in Part I, expressed in terms of the tensile stress f_s are

$$N = K_s \frac{f_s}{m} bd \quad . \quad . \quad . \quad . \quad (1a)$$

$$M_t = Ne_t = S_t \frac{f_s}{m} bd^2 \quad . \quad . \quad . \quad . \quad (2a)$$

$$M_c = Ne_c = S_c \frac{f_s}{m} bd^2 \quad . \quad . \quad . \quad . \quad (3a)$$

where K_s, S_t, and S_c are the stress factors for f_s, and $K_s = \dfrac{S_t - S_c}{1 - \beta'}$.

Shape Factors.—The stress-block factors κ_1, κ_2 and κ_3 may be expressed in

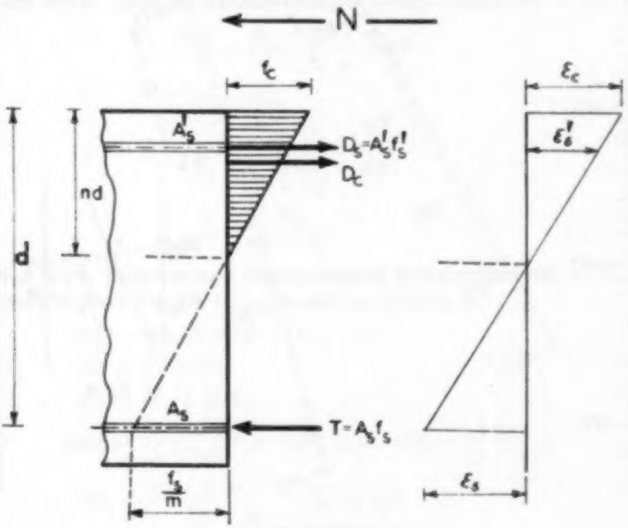
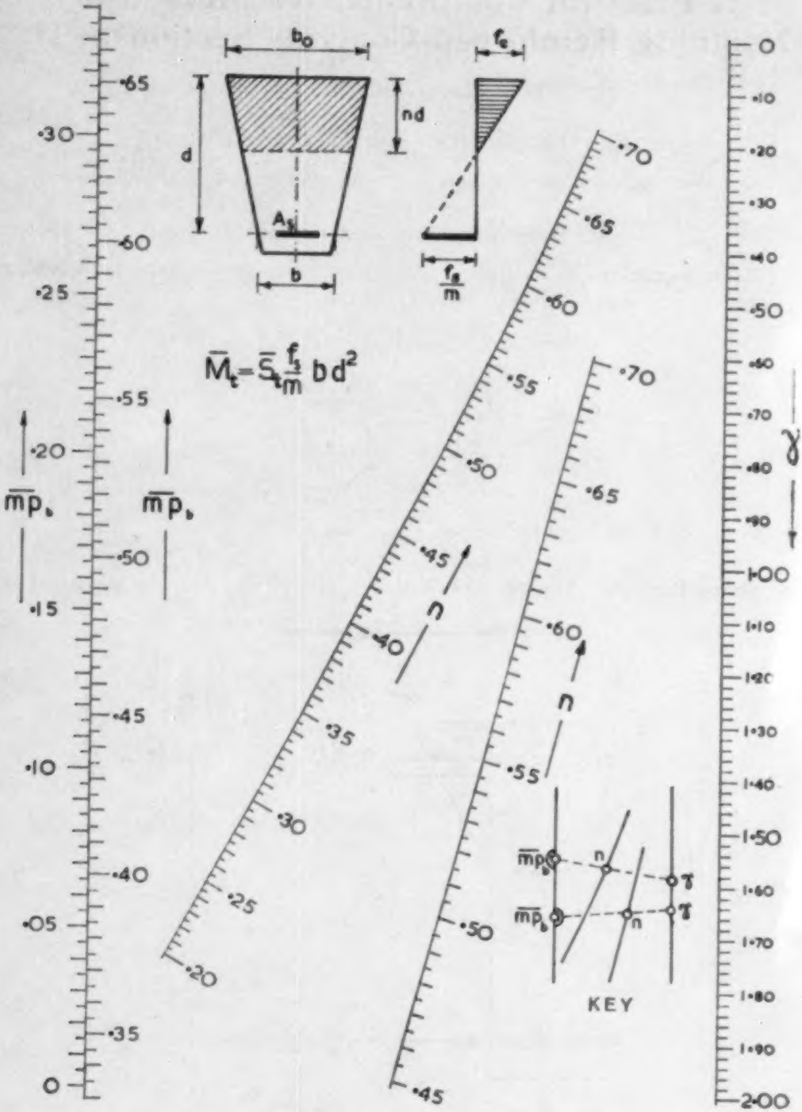


Fig. 7.

*Continued from June, 1961.



Nomogram No. 1.

the form $\kappa_1 = \frac{\phi_1}{n}$, $\kappa_2 = \frac{\phi_2}{n}$ and $\kappa_3 = \frac{\phi_3}{n}$, where ϕ_1, ϕ_2 and ϕ_3 are dependent on the shape of the compression zone only and are termed the shape factors.

Stress-factor Equations.—The stress factors may be expressed directly in terms of the shape factors and modular and reinforcement ratios thus.

$$K_c = \frac{\phi_1 + (n - \beta')(m - 1)p' - (1 - n)mp}{n} \quad . \quad . \quad . \quad (13)$$

$$C_t = \frac{\phi_2 + (n - \beta')(1 - \beta')(m - 1)p'}{n} \quad . \quad . \quad . \quad (14)$$

$$C_c = \frac{-\phi_3 + (1 - n)(1 - \beta')mp}{n} \quad . \quad . \quad . \quad . \quad (15)$$

$$K_s = \frac{\phi_1 + (n - \beta')(m - 1)p' - (1 - n)mp}{1 - n} \quad . \quad . \quad (16)$$

$$S_t = \frac{\phi_2 + (n - \beta')(1 - \beta')(m - 1)p'}{1 - n} \quad . \quad . \quad . \quad (17)$$

$$S_c = \frac{-\phi_3 + (1 - n)(1 - \beta')mp}{1 - n} \quad . \quad . \quad . \quad . \quad (18)$$

Simple Bending.—For simple bending $K_c = K_s = 0$, $C_t = C_c = C$ and $S_t = S_c = S$; therefore $\phi_1 + (n - \beta')(m - 1)p'_b - (1 - n)mp_b = 0$.

It should be noted that the moment of inertia I of the transformed concrete section can be expressed as μbd^3, where $\mu = Cn = S(1 - n)$.

Section with Tension Reinforcement Only.—Since $(m - 1)p' = 0$,

$$\bar{K}_c = \frac{\phi_1}{n} - \frac{(1 - n)}{n}\bar{m}\bar{p} \quad . \quad . \quad . \quad . \quad (13a)$$

$$\bar{C}_t = \frac{\phi_2}{n} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14a)$$

$$\bar{K}_s = \frac{\phi_1}{(1 - n)} - \bar{m}\bar{p} \quad . \quad . \quad . \quad . \quad . \quad (16a)$$

$$\bar{S}_t = \frac{\phi_2}{(1 - n)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (17a)$$

Section with Tension and Compression Reinforcement.—The relationships derived in Part I may be expressed as follows.

$$mp = \bar{m}\bar{p}_b + \Delta mp - K_s$$

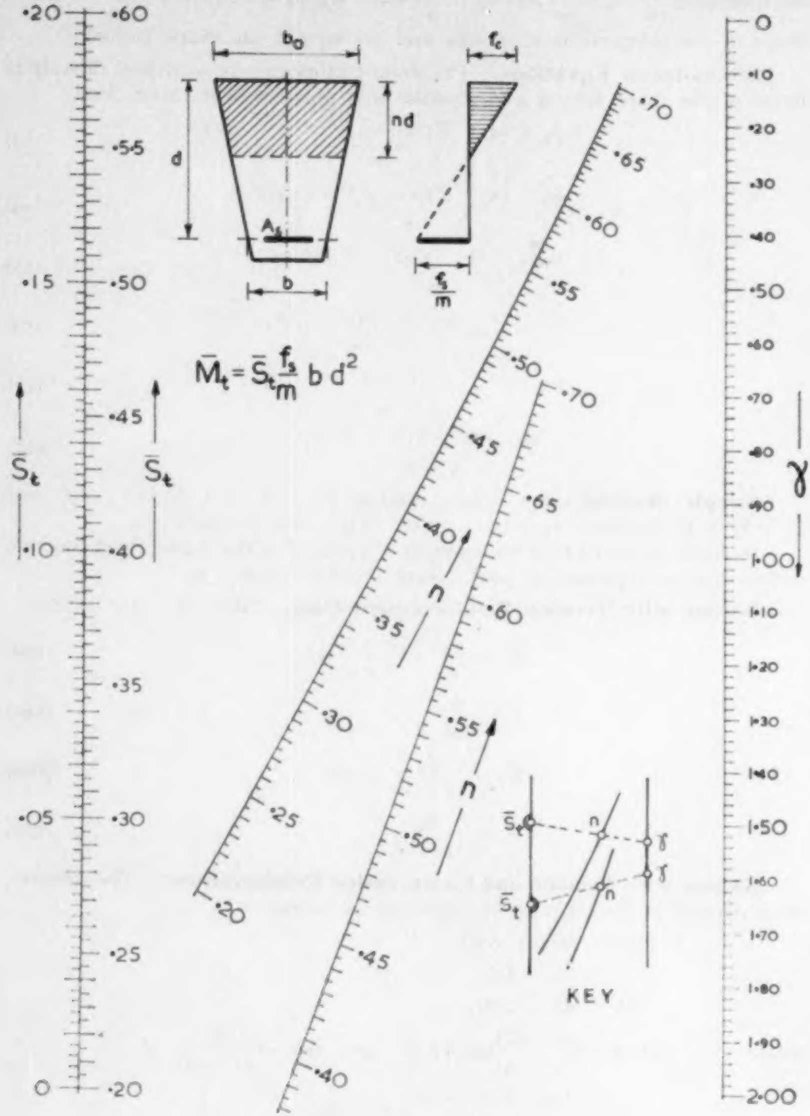
$$S_t = \bar{S}_t + \Delta S_t$$

$$M_t = \bar{M}_t + \Delta M_t$$

where $\Delta mp = \frac{(n - \beta')}{(1 - n)}(m - 1)p'$ and $\bar{m}\bar{p}_b = \frac{\phi_1}{(1 - n)}$,

$$\Delta S_t = \frac{(n - \beta')(1 - \beta')}{(1 - n)}(m - 1)p'$$

and $\Delta M_t = \Delta S_t \frac{f_s}{m} bd^2$.



Nomogram No. 2.

Application of Method.

The examples which follow illustrate the application of the method. Nomograms are given to enable the calculations to be made quickly and easily.

Nomograms Nos. 1 and 2 apply to a general trapezoidal section, particular cases of which are a triangular section ($\gamma = 0$) and a rectangular section ($\gamma = 1$). The equations on which these nomograms are based are as follows.

Nomogram No. 1 (page 248).— $\bar{m}\bar{p}_b = \dfrac{n^3}{6(1-n)} + \gamma\dfrac{n^2(3-n)}{6(1-n)}$

Nomogram No. 2 (page 250).— $S_t = \dfrac{n^2(2-n)}{12(1-n)} + \gamma\dfrac{n^2(6-4n+n^2)}{12(1-n)}$

The shape of a trapezoidal section (*Fig.* 8a) is described by the ratio $\gamma = b_o/b$, where b_o is the breadth of the section at the extreme compression edge and b is the breadth of the section at the centroid of the tension reinforcement. Sections such as those in *Figs.* 8(b) and (c) can be treated as trapezoidal if the neutral axis falls within the inclined sides of the section; b is obtained by projecting the inclined sides down to the centroid of the tension reinforcement.

As rectangular sections occur frequently, other nomograms, enabling solutions for such sections, when, reinforced in tension and compression, to be obtained even more rapidly and simply than by using Nomograms Nos. 1 and 2, have been prepared and will be included in Part III.

A design is either a *balanced design*, in which the position of the neutral axis $= n_o$ and is based on the permissible stresses being attained simultaneously, or is controlled by *the resistance of the tension reinforcement*, in which case $n < n_o$, or *the resistance of the concrete* in compression, in which case $n > n_o$.

Examples of Use of Nomograms Nos. 1 and 2.

EXAMPLE No. 1. Given.—Trapezoidal section. $b = 12$ in. $b_o = 18$ in.

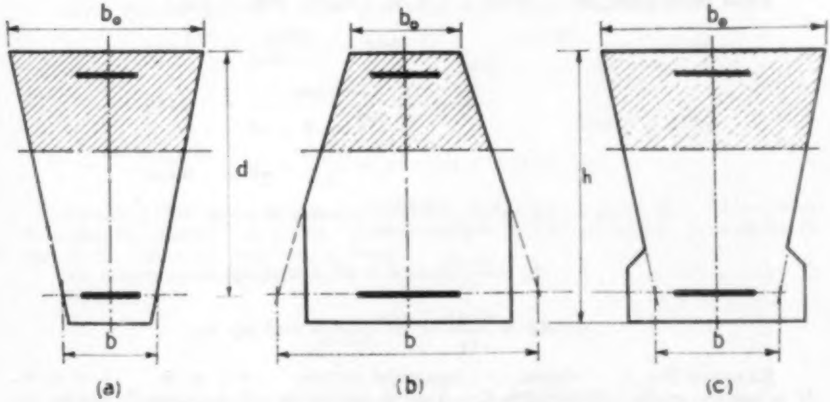


Fig. 8.

$d = 27$ in. $M = 2{,}000{,}000$ in.-lb. Permissible $f_c = 1100$ lb. per sq. in. $f_s = 20{,}000$ lb. per sq. in. $m = 15$.

To determine.—A_s (and A_s' if required), and actual stress in concrete (or reinforcement).

Solution.—$\gamma = \frac{b_o}{b} = \frac{18}{12} = 1{\cdot}5$, $n_o = 0{\cdot}452$.

$$S_t = \frac{2{,}000{,}000}{\frac{20{,}000}{15} \times 12 \times 27^2} = 0{\cdot}171.$$

From Nomogram No. 2 (with $\gamma = 1{\cdot}5$, $\bar{S}_t = 0{\cdot}171$), $n = 0{\cdot}404$, and as this is less than $n_o = 0{\cdot}452$, compression reinforcement is not required.

From Nomogram No. 1 (with $\gamma = 1{\cdot}5$, $n = 0{\cdot}404$), $\bar{m}\bar{p}_b = 0{\cdot}198$; hence

$$A_s = \frac{0{\cdot}198}{15} \times 12 \times 27 = 4{\cdot}28 \text{ sq. in.}$$

$$f_c = \left(\frac{n}{1-n}\right)\frac{f_s}{m} = \frac{0{\cdot}404}{1 - 0{\cdot}404} \times \frac{20{,}000}{15} = 904 \text{ lb. per sq. in.}$$

EXAMPLE No. 2. Given.—Rectangular section. $h = 30$ in. $b = 18$ in. $g = g' = 2$ in. $N = 80{,}000$ lb. (compressive). $e = 35$ in. Permissible $f_c = 1200$ lb. per sq. in. $f_s = 20{,}000$ lb. per sq. in. $m = 15$; hence $n_o = 0{\cdot}473$.

To determine.—A_s (and A_s' if required).

Solution.—$d = 30 - 2 = 28$ in.; $\beta = \beta' = \frac{2}{28} = 0{\cdot}07$.

$$e_t = 35 + \frac{30}{2} - 2 = 48 \text{ in.}; \quad e_c = 35 - \frac{30}{2} + 2 = 22 \text{ in.}$$

$$M_t = 80{,}000 \times 48 = 3{,}840{,}000 \text{ in.-lb.}; \quad M_c = 80{,}000 \times 22 = 1{,}760{,}000 \text{ in.-lb.}$$

$$S_t = \frac{3{,}840{,}000}{\frac{20{,}000}{15} \times 18 \times 28^2} = 0{\cdot}204.$$

From Nomogram No. 2 (with $\gamma = 1$, $n = 0{\cdot}473$), $\bar{S}_t = 0{\cdot}179$. Since $S_t > \bar{S}_t$, compression reinforcement is required; $\Delta S_t = 0{\cdot}204 - 0{\cdot}179 = 0{\cdot}025$.

From Nomogram No. 1 (with $\gamma = 1$, $n = 0{\cdot}473$), $\bar{m}\bar{p}_b = 0{\cdot}213$

$$\Delta mp = \frac{0{\cdot}025}{1 - 0{\cdot}07} = 0{\cdot}027$$

$$-K_s = \frac{-80{,}000}{\frac{20{,}000}{15} \times 18 \times 28} = -0{\cdot}119$$

$$mp = 0{\cdot}121$$

$$(m-1)p' = \frac{1 - 0{\cdot}473}{0{\cdot}473 - 0{\cdot}07} \times 0{\cdot}027 = 0{\cdot}035.$$

$$A_s = \frac{0{\cdot}121}{15} \times 18 \times 28 = 4{\cdot}07 \text{ sq. in.}$$

$$A_s' = \frac{0{\cdot}035}{14} \times 18 \times 28 = 1{\cdot}26 \text{ sq. in.}$$

EXAMPLE No. 3. Given.—Trapezoidal section. $d = 22$ in. $b = 15$ in. $M = 920{,}000$ in.-lb. Permissible $f_c = 1000$ lb. per sq. in. $f_s = 18{,}000$ lb. per sq. in. $m = 15$; hence $n_o = 0{\cdot}455$.

To determine.—b_o and A_s.

Solution.— $$S_t = \frac{920{,}000}{\frac{18{,}000}{15} \times 15 \times 22^2} = 0\cdot106$$

From Nomogram No. 2 (with $\bar{S}_t = 0\cdot106$, $n = 0\cdot455$), $\gamma = 0\cdot60$, therefore $b_o = \gamma b = 0\cdot60 \times 15 = 9$ in.
From Nomogram No. 1 (with $\gamma = 0\cdot60$, $n = 0\cdot455$), $\bar{m}\bar{p}_b = 0\cdot127$, hence

$$A_s = \frac{0\cdot127}{15} \times 15 \times 22 = 2\cdot79 \text{ sq. in.}$$

Example No. 4. Given.—Trapezoidal section. $d = 14$ in. $b = 12$ in. $b_o = 9$ in. $A_s = 1\cdot23$ sq. in. $A_s' = 0$. $m = 15$. $M = 250{,}000$ in.-lb.
To determine.—f_s and f_c.

Solution.—$\gamma = \frac{b_o}{b} = \frac{9}{12} = 0\cdot75$. $\bar{m}\bar{p}_b = \frac{15 \times 1\cdot23}{12 \times 14} = 0\cdot110$.

From Nomogram No. 1 (with $\gamma = 0\cdot75$, $\bar{m}\bar{p}_b = 0\cdot110$), $n = 0\cdot405$.
From Nomogram No. 2 (with $\gamma = 0\cdot75$, $n = 0\cdot405$), $\bar{S}_t = 0\cdot094$.

$$f_s = 15 \times \frac{250{,}000}{0\cdot094 \times 12 \times 14^2} = 16{,}960 \text{ lb. per sq. in.}$$

$$f_c = \frac{0\cdot405}{1 - 0\cdot405} \times \frac{16{,}960}{15} = 770 \text{ lb. per sq. in.}$$

Example No. 5. Given.—Trapezoidal section. $b = 12$ in. $b_o = 21$ in. $g' = 3$ in. $N = 100{,}000$ lb. (compressive). $e = 25$ in. Permissible $f_c = 1000$ lb. per sq. in. $f_s = 20{,}000$ lb. per sq. in. $m = 15$; hence $n_o = 0\cdot429$. $A_s' = 0$.
To determine.—d and A_s.

Solution.—$\gamma = \frac{21}{12} = 1\cdot75$.

From Nomogram No. 2 (with $\gamma = 1\cdot75$, $n = 0\cdot429$), $\bar{S}_t = 0\cdot228$.
The required effective depth, d, can be determined from equation (2a) rewritten in the the form $N\left(e + \frac{d - g'}{2}\right) = \bar{S}_t \frac{f_s}{m} bd^2$,

that is $100{,}000 \times \left(25 + \frac{d - 3}{2}\right) = 0\cdot228 \times \frac{20{,}000}{15} \times 12 \times d^2$ from which $d = 33$ in.
From Nomogram No. 1 (with $\gamma = 1\cdot75$, $n = 0\cdot429$), $\bar{m}\bar{p}_b = \quad 0\cdot268$

$$-K_s = \frac{-100{,}000}{\frac{20{,}000}{16} \times 12 \times 33} = -0\cdot189$$

$$\bar{m}\bar{p} = \overline{\quad 0\cdot079}$$

$$A_s = \frac{0\cdot079}{15} \times 12 \times 33 = 2\cdot09 \text{ sq. in.}$$

Example No. 6. Given.—Triangular section. $d = 14$ in. $b = 18$ in. $N = 7000$ lb. (tensile). $e_t = 7$ in. Permissible $f_c = 880$ lb. per sq. in. $f_s = 16{,}000$ lb. per sq. in. $m = 12$; hence $n_o = 0\cdot398$.
To determine.—A_s (and A_s' if required).
Solution.—

$$S_t = \frac{7000 \times 7}{\frac{16{,}000}{12} \times 18 \times 14^2} = 0\cdot0104.$$

From Nomogram No. 2 (with $\gamma = 0$, $\bar{S}_t = 0\cdot0104$), $n = 0\cdot365$.
As $n < n_o$ therefore compression reinforcement is not required.

From Nomogram No. 1 (with $\gamma = 0$, $n = 0{\cdot}365$), $\bar{m}\bar{p}_b = 0{\cdot}0127$

$$-K_s = -\frac{-7000}{\frac{16{,}000}{12} \times 18 \times 14} = 0{\cdot}0208$$

$$\bar{m}\bar{p} = 0{\cdot}0335$$

$$A_s = \frac{0{\cdot}0335}{12} \times 18 \times 14 = 0{\cdot}704 \text{ sq. in.}$$

$$f_c = \frac{0{\cdot}365}{1 - 0{\cdot}365} \times \frac{16{,}000}{12} = 766 \text{ lb. per sq. in.}$$

EXAMPLE No. 7. Given. — Rectangular section. $b = 12$ in. $g = 1{\cdot}75$ in. $N = 14{,}000$ lb. (compressive). $e = 22$ in. Permissible $f_c = 1000$ lb. per sq. in. $f_s = 20{,}000$ lb. per sq. in. $m = 15$; hence $n_0 = 0{\cdot}429$. $A_s' = 0$.

To determine.—d and A_s.

Solution.—Assume $\beta' = 0{\cdot}14$. From Nomogram No. 1 (with $\gamma = 1$, $n = 0{\cdot}429$), $\bar{m}\bar{p}_b = 0{\cdot}161$. From Nomogram No. 2 (with $\gamma = 1$, $n = 0{\cdot}429$), $S_t = 0{\cdot}138$. The eccentricity factor is given by $U_s = \dfrac{N}{\frac{f_s}{m}eb} = \dfrac{14{,}000}{\frac{20{,}000}{15} \times 12 \times 22} = 0{\cdot}398,$

d can be determined from the equation $\varepsilon_0\left(\varepsilon_0 + \dfrac{1 - \beta'}{2}\right) = \dfrac{S_t}{U_s}$, that is

$$\varepsilon_0(\varepsilon_0 + 0{\cdot}43) = \frac{0{\cdot}138}{0{\cdot}0398} = 3{\cdot}46,$$

from which $\varepsilon_0 = 1{\cdot}66$ and therefore $d = \dfrac{e}{\varepsilon_0} = \dfrac{22}{1{\cdot}66} = 13{\cdot}25$ in.

Checking assumed value of β.— $\beta = \dfrac{1{\cdot}75}{13{\cdot}25} = 0{\cdot}13$ which is about the value assumed.

$$\bar{K}_s = \frac{14{,}000}{\frac{20{,}000}{15} \times 12 \times 13{\cdot}25} = 0{\cdot}066. \quad \bar{m}\bar{p} = \bar{m}\bar{p}_b - \bar{K}_s = 0{\cdot}161 - 0{\cdot}066 = 0{\cdot}095.$$

$$A_s = \frac{0{\cdot}095}{15} \times 12 \times 13{\cdot}25 = 1{\cdot}01 \text{ sq. in.}$$

EXAMPLE No. 8. Given. — Rectangular section. $g = 1{\cdot}5$ in. $N = 6300$ lb. (tensile). $e = 47$ in. Permissible $f_c = 900$ lb. per sq. in. $f_s = 20{,}000$ lb. per sq. in. $m = 15$; hence $n_0 = 0{\cdot}403$. $\bar{m}\bar{p} = 0{\cdot}175$. $A_s' = 0$.

To determine.—d and b.

Solution.—From Nomogram No. 1 (with $\gamma = 1$, $n = 0{\cdot}403$), $\bar{m}\bar{p}_b = 0{\cdot}136$. From Nomogram No. 2 (with $\gamma = 1$, $n = 0{\cdot}403$), $S_t = 0{\cdot}118$.

$$\bar{K}_s = \bar{m}\bar{p}_b - \bar{m}\bar{p} = 0{\cdot}136 - 0{\cdot}175 = -0{\cdot}039. \quad \varepsilon = \frac{S_t}{\bar{K}_s} = \frac{0{\cdot}118}{0{\cdot}039} = 3{\cdot}026.$$

Assuming $\beta = 0{\cdot}10$, $\varepsilon_0 = \varepsilon + \dfrac{1 - \beta}{2} = 3{\cdot}026 + \dfrac{1 - 0{\cdot}10}{2} = 3{\cdot}476$, and therefore

$$d = \frac{e}{\varepsilon_0} = \frac{47}{3{\cdot}476} = 13{\cdot}52 \text{ in., say } 13{\cdot}5 \text{ in.}$$

Checking assumed value of β.— $\beta = 1{\cdot}5/13{\cdot}5 = 0{\cdot}11$ which is about equal to the value assumed.

$$b = \frac{Ne_t}{S_t\frac{f_s}{m}d^2} = \frac{6300 \times (47 - 6)}{0{\cdot}118 \times \frac{20{,}000}{15} \times 13{\cdot}5^2} = 9{\cdot}0 \text{ in.}$$

(To be continued.)

Developments in the Ready-mixed Concrete Industry.

INTERESTING features of some ready-mixed concrete plants installed recently in Britain and of other activities in this branch of the concrete industry are described in the following.

A Plant in West Kent.

The plant illustrated in *Fig.* 1 has a rated capacity of 30 cu. yd. of concrete per hour. The aggregate is dredged from the bed of a lake and delivered to a washing, crushing, and screening plant, from which sand and various sizes of coarse aggregate are delivered by an inclined belt-conveyor to stockpiles located between the screening and concrete plants. The conveyor and some of the stockpiles are seen to the left in *Fig.* 1. Under the stockpiles, there is a concrete conveyor tunnel (*Fig.* 2), 274 ft. long, 5 ft. 6 in. wide and 6 ft. 6 in. high, in the roof of which there are thirteen hoppers through which the flow of materials from the stockpiles on to the belt-conveyor in the tunnel is controlled. The gate of a hopper in the closed position is shown in *Fig.* 2. The conveyor is 24 in. wide and travels at a speed of 300 ft. a minute. The gates are controlled from the cabin seen in *Fig.* 3. The levers operate stranded-wire cables, each of which is attached to a gate which opens when the lever is pulled forward. When the lever is released, the gate closes by means of a counterbalance.

At the exit from the tunnel, the conveyor rises at an angle of 25 deg., and delivers the material to a transverse conveyor (*Fig.* 4), which is suspended from a steel beam and tranverses four bins each of which is for an aggregate of a different size. The movement of the conveyor over the bins is controlled by the operator in the cabin (*Fig.* 3). The bins, each of which has a capacity of 7½ cu. yd., are over a pit into which descends the skip which delivers the materials to the elevated mixer (*Fig.* 5). The capacity of the skip is sufficient for the materials for 1 cu. yd. of concrete. The cement is stored in the two silos seen to the right in *Fig.* 5; one silo is for ordinary Portland

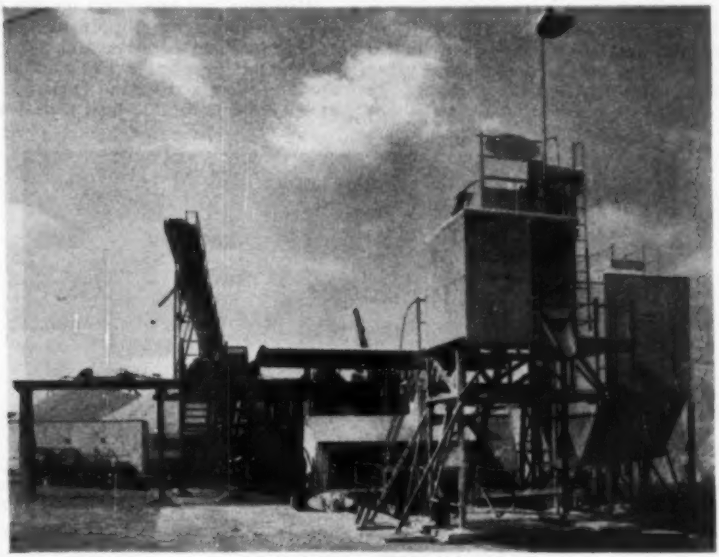


Fig. 1.—Plant near Sevenoaks.

cement and the other for rapid-hardening Portland cement; each silo has a capacity of 30 tons.

The operation of the mixing plant is semi-automatic. The material is weigh-batched by manual controls actuating the doors of the bins. The cement is transferred by air-slides from the silos to the weigh-batcher and is delivered by an electro-pneumatic system operated by a push-button from the control panel alongside the operator's seat (*Fig.* 6). Weighing is by sealed hydraulic capsule. All materials are weighed together, including the cement, as a total weight on the dial of the scale. The quantity of water required for each batch is set on a flowmeter by the operator. The contents of the weigh-batcher are emptied by pneumatic control into an elevating skip, and then a button is pressed to operate the hoisting mechanism of the skip, which discharges its contents into the mixer. At the same time the water-meter operates automatically, and the required quantity of water flows into the mixer. The mixer is a 1-cu. yd. horizontal-drum machine. When mixing is complete, a push-button is operated to cause the discharge of the concrete into a hopper, from which it is delivered along a chute to cone-shaped agitator drums on a lorry.

The aggregate plant is also used for supplying aggregates, either of mixed sizes or of one size, to destinations other than the ready-mixed concrete plant. In this case the transverse conveyor is not

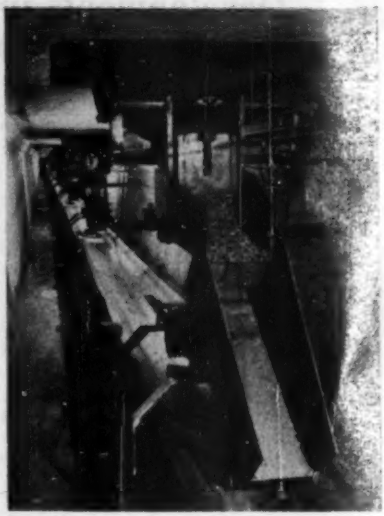


Fig. 2.

used since the material is delivered from the end of the main conveyor directly into lorries.

Two men are employed on the plant, one controlling the supply of aggregate to the bins over the mixer and one operating the mixing plant. The plant is operated by Messrs. Redland Quarries, Ltd., at Riverhead, Kent, which firm designed

Fig. 3.

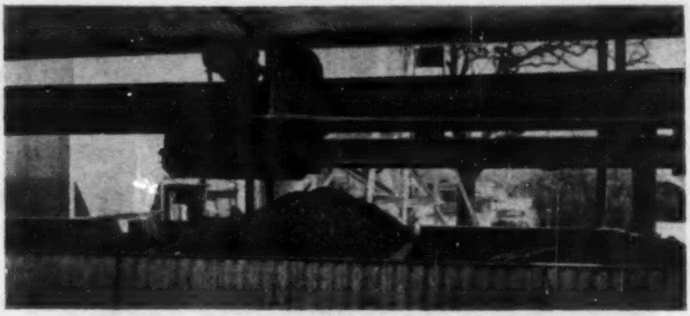


Fig. 4.

the arrangements for the transport and delivery of the aggregates and installed the whole of the plant.

A Plant in East Kent.

The plant illustrated in *Fig.* 7 was installed recently at Chilmington, near Ashford, and incorporates a new design of 1-cu. yd. pan-type mixer having a rated output of 60 cu. yd. per hour. The low-level batcher has storage capacity for 30 cu. yd. of aggregates in four compartments and is loaded from the stockpiles by a mobile tractor-shovel. The aggregate-weigher is of 42 cu. ft. capacity and weighing accuracy is assured by a patented hydraulic system. The feed-gates and discharge gates of the weigh hopper are electro-pneumatically operated by remote control from a main control panel near the mixer in the tower. The weigher discharges dry aggregates on to a troughed belt-conveyor which carries them to the mixer.

Two 30-ton cement silos are provided for the separate storage of ordinary and rapid-hardening Portland cement. The capacity of the storage of cement can be increased by connecting up additional silos by means of fluidising conveyors. The cement is weighed, independently of the aggregates, in a 800-lb. weighing apparatus. The cement silos being elevated, permit the cement to be discharged

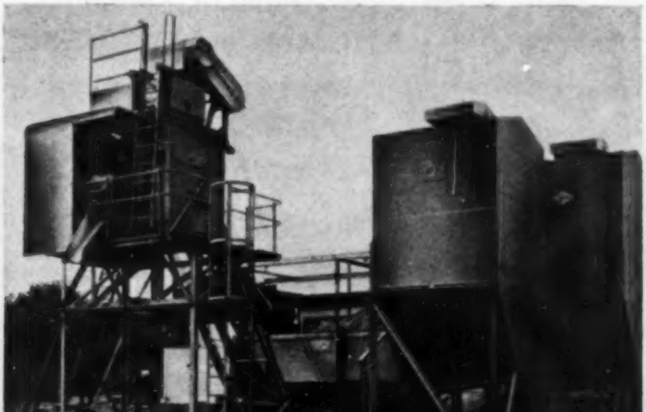


Fig. 5.—Plant near Sevenoaks.

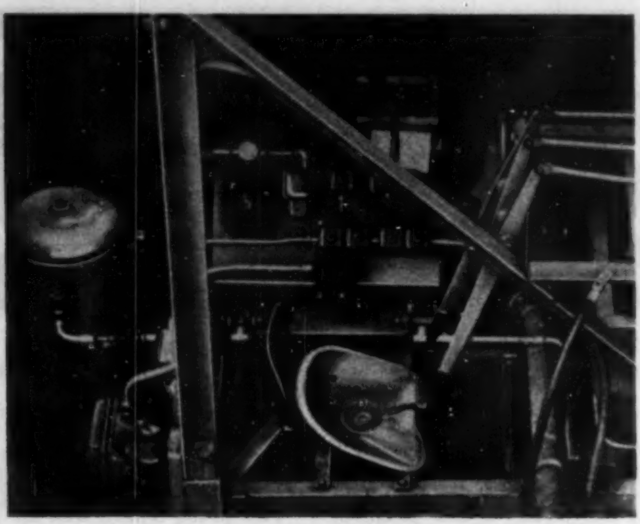


Fig. 6.

from the weigher directly into the pan of the mixer thereby obviating prior contamination of the cement by any moisture in the aggregates. Accurate measurement of the water is achieved by a flowmeter control. The mixer is mounted on an elevated platform thereby enabling it to discharge directly through a new type of swivelling telescopic discharge chute into agitators, mobile mixers or lorries.

The plant at Chilmington is operated by Nickolls Ready-mixed Concrete Co., Ltd.

The batching and mixing equipment and the cement silos for the plants at

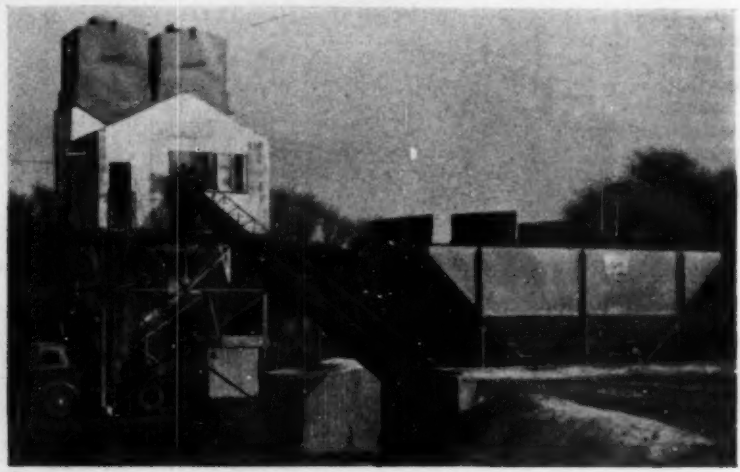


Fig. 7.—Plant near Ashford.

Riverhead and Chilmington were supplied by Blaw Know Ltd.

A Plant in Essex.

A ready-mixed concrete plant, which was installed recently at the new town of Harlow, Essex, is one of a number of purposed-designed plants planned to take advantage of irregularities in the levels of the sites at which the plants are to be erected. The advantage is mainly the omission of major types of equipment for handling materials.

In the plant at Harlow, an elevated bin for aggregate, having a capacity of 80 cu. yd., has four compartments and is mounted immediately over the batch weigh-hopper. The materials are tipped directly into the bin from lorries which approach the plant on a gantry extending from adjacent high ground. Open-mesh steel wheel-tracks span the bin to enable materials to be discharged into the compartments on the far side of the structure.

A 40-ton cement silo is provided on the side of the plant remote from the gantry. Cement is fed into the silo from pressurised tankers standing on a road at the lower ground level. A static bag-filter surmounts the silo to prevent building up of pressure during filling.

The weigh-hopper, which contains sufficient material for 4 cu. yd. of concrete, has two compartments.

The plant was designed and is owned by Ready Mixed Concrete (Eastern Counties) Ltd., in association with Messrs. Peters & Barham Ltd.

A Plant in Cheshire.

The concrete batching and mixing plant installed at the Sealand Trading Estate, Cheshire, is completely automatically controlled by one operator, at a push-button console, and is capable of producing 60 cu. yd. of ready-mixed concrete per hour. The aggregate storage hopper, having a total capacity of 48 cu. yd., is divided into four equal compartments, each having a twin outlet fitted with radial gates operated pneumatically by 4-in. cylinders. Beneath the hopper, and supported on the same structure, is an aggregate weigh-hopper carried in a precision batch-weigher. The weighing system is connected to a dial mounted on the operator's platform.

A twin-compartment, 30-ton cement silo is equipped with a pneumatic conveyor and blowing unit for delivery to a surge hopper of 10 tons capacity and having two compartments, each of which is fitted with a ventilator filter at the top. Supported on the same structure and beneath the surge hopper, there is a cement weigh-hopper which is also connected to a dial on the operator's platform. The weigher outlet is fitted with reverse radial gates operated pneumatically by 3-in. cylinders.

Before commencing production, the operator adjusts transistorised photo-electric scanning heads to give the required weight of aggregate and cement from each storage hopper. To begin production, the operator presses a "start" button for weighing aggregate and cement simultaneously. The respective doors open, and the materials discharge into the weigh hoppers; the doors close automatically when the predetermined quantity has been delivered. The action of the weight-recording pointer passing the photo-cells on the dial settings causes electrical impulses to pass to solenoid valves which in turn operate the cylinders. The aggregate doors continue to open and close in succession and lights on the control platform indicate when the weighing of both materials is complete. This part of the cycle being complete, the operator pre-sets the "unload for mixing" button and the aggregate is discharged on to an inclined belt-conveyor, which is 84 ft. long and discharges into a 1½-cu. yd. paddle-mixer. A time-delay apparatus ensures that the cement and aggregate discharge into the mixer simultaneously. Water is added by the operator, the amount being pre-set on a water-meter; a 3-in. pneumatic cylinder operates the valve controlling the flow of water. The opening of the valve is controlled by the operator but the closing is automatic on receipt of a signal from the water-meter.

In addition to the automatic controls, the operator has manual controls enabling him to weight directly. Electro-pneumatic control is also provided in the cement conveyor system to divert the flow of cement to one or other of the silos when being filled from the blowing unit. The adjustable chute beneath the mixer is designed to discharge into mobile mixers or open lorries.

The mixing plant, control console, switchgear and the vehicle loading position are totally enclosed in a housing of

steel frame and asbestos sheeting. The fact that this plant is operating at a city boundary raised problems of height, appearance, noise and dust. By installing the aggregate weigh-hopper and elevator below ground level, the overall height of the aggregate storage unit was reduced. Pneumatic control, the provision of rubber and canvas conveyor belts with ball-bearing rollers, and the quiet-running paddle-mixer combine to reduce noise to a minimum.

The plant was designed and manufactured by Millar's Machinery Co., Ltd., and is owned by John Henshall (Quarries) Ltd.

A Record Supply.

In connection with the foundations of the new Hilton hotel being erected in Park Lane, London, 1185 cu. yd. of ready-mixed concrete was delivered and placed in a period of twelve hours. To achieve this quantity without interrupting supplies to other contracts, the suppliers combined the outputs of three plants in the London area. Delivery was made in transit mixers of capacities varying from 3 to 6 cu. yd. Supplies arrived at the site at intervals of 2½ minutes.

The transit mixers stood on the road 60 ft. above the foundation being constructed and discharged the concrete through extension chutes fitted to the vehicles into flexible metal trunking through which the concrete was fed to the lower level of the site. To assist in transporting the concrete to the central area of the foundation, the concrete was discharged from the trunking into hoppers from which it was discharged on to two belt-conveyors. Each vehicle was despatched from the site within five minutes of its arrival.

The contractors are the Token Construction Co., Ltd., and the concrete was supplied by the Ready Mixed Concrete Co., Ltd.

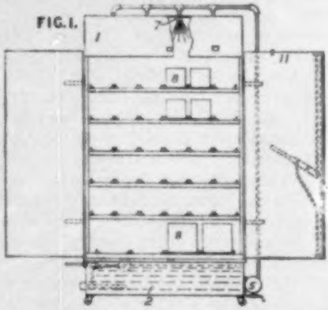
Bulletin Received.

"Preconditioning and Stabilizing Soils by Lime Admixtures." Bulletin No. 262. Highway Research Board. (1960. Price 1.80 dollars.)

Patent Applications for Curing Concrete.

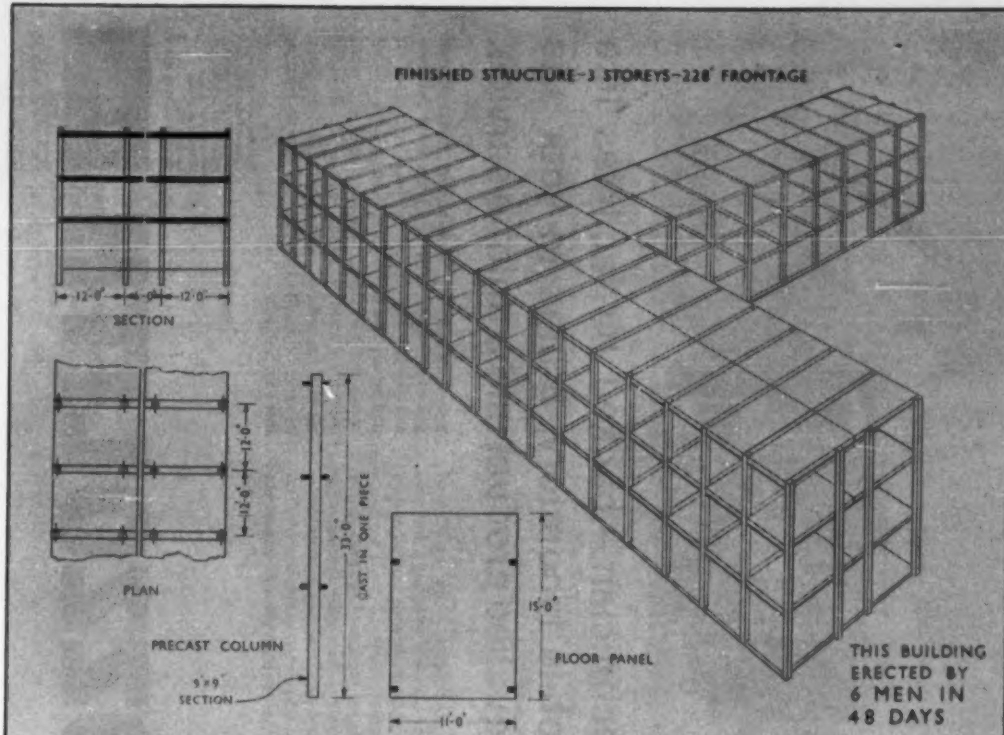
APPARATUS for curing concrete test specimens 8 comprises a cabinet 1, a water reservoir 2 and a pump 5 which circulates water in the cabinet via spray nozzles 7 to maintain a predetermined level of humidity which is usually 90%. The specimens are heated by an electric heater,

FIG. I.



the temperature being maintained between 60° F.—80° F. by a thermostat while a limit switch, *Fig.* 3 (not shown), is arranged to cut off the water pump 5 when the cabinet door 11 is opened. A humidity meter regulating the output of the water pump may also be fitted.—No. 845,380. Simon-Carves Ltd. December 30, 1958.

Concrete is cured by spraying thereon a membrane-forming composition in which is dispersed aluminium in leaf or powder form protected against chemical attack by alkaline salts in the fresh concrete. Protective agents specified are metal soaps such as calcium and zinc stearates; these also assist in dispersing the aluminium in the composition. Organic solvents in a proportion of e.g. 2 to 4 per cent. by weight, such as carbon tetrachloride, trichloroethylene or petroleum solvents obtained by distillation, may be added to facilitate mixing the aluminium with the composition. In examples are described membrane-forming compositions consisting of aluminium paste, carbon tetrachloride or white spirit, calcium or zinc stearate, and a curing composition having the Registered Trade Mark "Ritecure". Proportions of aluminium paste and metallic soap are 2 to 4 per cent., and up to 4 per cent., respectively.—No. 846,885. J. Laing & Son Ltd. August 7, 1956.



Modular concrete

THE MODULAR CONCRETE COMPANY LIMITED

Construction Division, 1280 London Road, Norbury S.W.16

TELEPHONE: POLLARDS 8000

The structure illustrated indicates just one of the services offered by the Modular Concrete Co. Ltd. A prefabricated building on a 12′ × 12′ column grid with a 6′ corridor between. Plan form and height variable.

It consists of TWO components:—

33′ columns cast in one length
15′ × 11′ floor slabs with integrated perimeter beams.

Columns contain fabricated steel shear connectors on to which the floor slabs seat directly without propping. The method makes for extremely quick and safe erection procedure and eliminates hazards often associated with connection of precast elements.

All services can be catered for quite simply.

Speed and economy result from SIMPLICITY AND REPETITION—attained by this example of OPTIMUM PREFABRICATION.

Write or 'phone Modular for further details.

Failures of Foundations.

An interesting and informative book* on the unusual subject of failures of foundations was published recently. Numerous examples of defective foundations and defective structures due to failure of foundations, in many parts of the world, are described and examined. The causes and prevention of like failures are discussed. Of particular interest are the examples drawn from Central Europe, details of many of which have not been available before. Other well-known failures are re-examined.

The author is Professor of Foundation Engineering at the University of Civil Engineering and Architecture at Budapest, and is the author of a similar book published in Hungary. In the present publication there are, however, very many additional examples including some from Great Britain. Although the soil-mechanics aspect of the subject is given due prominence, there is a commendable absence of mathematics and there is much common sense.

Some opinions of the book are given in the following.

Mr. G. P. Manning writes as follows.

When the Foundations Code No. 4 was being drafted I suggested that British engineers should collect and publish details of their foundation failures. The horrified silence that ensued is still unbroken. Therefore the publication of this book is a most notable addition to our technical literature and is worthy of the attention of every practising civil engineer.

It is difficult to criticise any structural design without knowing something of the background, including the economic conditions and national outlook. Several of the foundations described are deliberately placed on new earth filling where, in Great Britain, we should invariably use mass concrete in place of filling. The saving in cost would be trivial in this country, and the use of gravel filling instead of lean concrete indicates the need for saving in first cost. Accepting this premise as the first and over-riding necessity, the examples and the remedies suggested by the author appear much more rational than they would otherwise seem. Although the reader may occasionally disagree with the author's explanations they are clearly the result of much thought and always worth careful consideration.

Mr. Leslie Turner writes as follows.

The author and publishers are to be congratulated on the production of this book. The illustrations and charts are in English and all dimensions have been converted into English units. The subject is vast, combining an understanding of geology, soil mechanics and structural design, aspects of all of which must be considered together. Each example is unique, as it must be in practice and rarely recurs in detail although the underlying correlations are obvious and must be absorbed by all qualified structural designers.

In the design of column footings on clay, more stress should be laid on designing for equal settlement rather than for uniform ground pressure. This is the requisite for perfect foundations, often unattainable, and requires full knowledge of the ground and the outline and loading of the superstructure; but it can be achieved more often than it actually is. Foundation design is still an art as well as a science. The interpretation of results of soil-mechanics investigations is the responsibility of the engineer.

Brief references are made in the book to volumetric changes of soil due to frost and heat, tree roots and other vegetation, and the swelling of clay soils. It is often found that these cases are difficult to solve successfully. For instance, the position of a chimney stack in relation to a brick kiln is critical if the works are on clay, as is usual; the deflection from the vertical of some chimneys at brickworks is most apparent and is due to this cause. The effects of tree roots is an extensive subject including the laws of the country, which were formulated long before a study of these effects was made.

The damage to structures by expansive clays, such as occur in South Africa, is an interesting study. The phenomena are widespread there and have caused much structural damage to large and small buildings. For instance, bungalows built on the veldt for the new goldmines may

* "Foundation Failures." By C. Széchy. [London: Concrete Publications Ltd. 1961. Price 20s. In Canada and U.S.A. 5.0 dollars.]

rise some 4 in. towards their centres on plan; this upheaval, the effect of which on doors, windows and partitions can be imagined, took place slowly during the first three to four years. Preventive measures, the cost of which is high in comparison with the total cost of the structure, may range from the provision of tension piles to special preparation of the site prior to construction.

It is hardly possible to deal in detail with such problems as these in a first edition, particularly when the information is so widely scattered and not readily available. Dr. Széchy has done a fine job in collecting so many different examples all of which are instructive to civil and structural engineers.

Mr. Donovan H. Lee writes as follows.

There is a wealth of cases of failures described in this book; some are historic, like the Transcona silos in Canada, and a number in Western Europe and Britain, for example the railway cutting at Wembley which slipped in 1918. About half of the cases are from the author's native country, Hungary, and it may surprise some readers to learn how many failures of foundations there are; unfortunately there must be a great number in almost every country, and because of this a book of this type is likely to be valuable in every civil engineer's library.

The technical descriptions are mostly very clear and the related illustrations and graphs or diagrams are in general easily followed; in a few cases, however, they cannot be followed without some patience. The causes of practically all the failures are convincingly explained, and in many cases detailed data of the properties of the soil are given or the defects in the design or execution of the structure, or the temporary works as the case may be, are described.

Students and young engineers may find it of great interest to see the consequences of a retaining wall without weep holes, excessive bearing pressure on cohesive soils, the possible consequences of excavating alongside and below existing loaded foundations and the inadequate bracing of cofferdams, and other defects in execution. The more experienced engineer may find of more interest the failures due to excessively rigid foundations, foundations of different types under the same building, and other but not so obvious causes such as an example of trouble caused by unnecessary piling.

The publication of this book immediately prior to the Sixth International Congress of Soils Mechanics and Foundation Engineering, which is being held in Paris this month, is timely, though fortuitous.

Tay Road Bridge.

The proposals for a road bridge over the Firth of Tay include a bridge structure 7470 ft. in length costing about £4,000,000. The construction would be of prestressed concrete and would provide two 24-ft. carriageways. The two main navigation spans would each be 240 ft. long. The viaduct on the northern side of the navigation spans would comprise thirty-seven spans of 120 ft. each and four shorter spans, and on the southern side eighteen spans of 120 ft. each and one shorter span. The foundations would comprise piles driven down to rock. The site of the bridge would be east of the existing railway bridge. The clearance under the navigation spans would be about 78 ft. above mean tide level.

The consulting engineer to the Tay Road Bridge Joint Committee is Mr. W. A. Fairhurst.

An Honour.

Mr. W. A. Fairhurst, M.I.Struct.E., senior partner in the firm of consulting engineers Messrs. F. A. Macdonald & Partners, has been appointed Commander of the Order of the British Empire. Among the notable works for which he and his firm are responsible is the Queen's Bridge, Perth, which is described in this journal for August 1960 and was opened by Her Majesty the Queen. Mr. Fairhurst is the author of "Arch Design Simplified" and joint-author of "Design and Construction of Reinforced Concrete Bridges."

Bulletin Received.

"Repair of Structures and Pavement by Thin Concrete Patching." Bulletin No. 260. Highway Research Board. (1960. Price 0.60 dollars.)—Contains reports on "Latex-modified Mortar in the Restoration of Bridge Structures" by S. M. Cardone, M. G. Brown, and A. A. Hill, and "Bonded Resurfacing and Repairs of Concrete Pavements" by W. G. Westall.

Vehicles for Ready-mixed Concrete.

PARTICULARS are given in the following of recent developments in the construction of transit mixers for the supply of ready-mixed concrete.

A Lightweight Mixer.

Fig. 1.

The drum of a new 4-cu. yd. transit mixer (*Fig.* 1) exhibited at the Commercial Vehicle Show last year is constructed of aluminium, and thereby the weight is reduced by 12 cwt. from that of similar steel drums which weigh about 3 tons. The power required for agitating the concrete is 5 h.p., for charging 9 h.p., and for discharging 2·4 h.p. The drum rotates at a speed of 7 to 10 r.p.m., 7 to 12 r.p.m., and 10 to 20 r.p.m., respectively during these operations. A 120-gallon tank for the mixing water and a 16-gallon tank for flushing out the drum are situated behind the driver's cabin, and their contents are controlled by a flow-meter and check-valve. The mixing-drum unit was developed by the British Aluminium Co., Ltd., and made by Messrs. Melling & Bath, Ltd. The vehicle was designed and built by Messrs. Davies Brothers (Denton) Ltd.

A Large Capacity Mixer.

What is claimed to be the transit mixer (*Fig.* 2) having the largest capacity in this country went into service recently. It is of 9-cu. yd. capacity and is mounted on an eight-wheel chassis incorporating the latest form of hydrostatic drive. To keep the total weight to a minimum, the vehicle is operated by a two-stroke engine and has a glass-fibre driving cab. In order not to exceed the limit of 24 tons for an eight-wheel commercial vehicle, as imposed by the Ministry of Transport regulations, the carrying capacity is restricted to 8 cu. yd. Two of these vehicles are in service with Ready Mixed Concrete Ltd., and others are to be added to that company's fleet of about four-hundred vehicles. The mixing unit was manufactured by Messrs. Ransome & Rapier Ltd.

Fig. 2.

Fig. 3. (*See page 264.*)

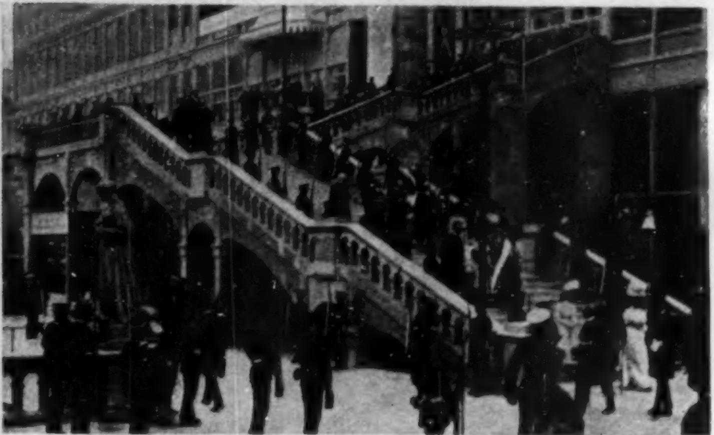
Hydraulic-drive Mixer.

A new transit mixer introduced at the Public Works Exhibition last year has a hydraulic drive and the capacities of the drum are 3½, 4 and 6 cu. yd. One control lever only actuates charging, agitating, mixing and discharging operations; hydraulic operation eliminates the use of cables and rods. Two control units are provided, one being in the driver's cab and the other at the rear of the vehicle. A meter indicates the correct speed for the various operations and also records a running total of the number of revolutions of the drum between charging and mixing for each journey. The mixer, an illustration of which is given in *Fig*. 3, is produced by Winget Ltd.

FIFTY YEARS AGO.

From "CONCRETE AND CONSTRUCTIONAL ENGINEERING", July, 1911.

Ornamental Concrete Stairways.



THE illustration shows H.M. King George V and Queen Mary descending one of the stairways at the Crystal Palace, London, on the occasion of the Festival of Empire, which was held in the summer of 1911. Since that date there have been three sovereigns, the Empire has been attenuated, and the Crystal Palace has been burnt down, but some of the ornamental concrete stairways are intact. The stairways were designed by Mr. Burnard Geen and constructed by the Empire Stone Co., Ltd. The terrace adjacent to the stairways was the site last month (June 1961) of the International Construction Equipment Exhibition.

A Russian Hydro-electric Works.

ONE of the exhibits at the Russian Trade Fair which is being held in London during the present month is a model of a hydro-electric power station being built at Bratsk in Eastern Siberia. Having a capacity of 4,500,000 kw., the station, which is due to start operating towards the end of this year, will be probably the largest hydro-electric station in the world. The works, which is being constructed at the Padun Gorge on the River Angara, includes a concrete gravity dam 420 ft. high reduced in weight by hollow deformation joints. The project involved the excavation of 5,000,000 cu. yd. of earth and rock, placing 17,000,000 cu. yd. of earth and rock filling, and placing 7,500,000 cu. yd. of concrete including reinforced concrete.

Six hydro-electric power stations are to be built on the River Angara of which the Bratsk project is the second. A station to be built on the Yenisei is to have a capacity of about 6,000,000 kw.

DATA FOR PRICING REINFORCED CONCRETE.

MATERIALS (*Delivered London*).

AGGREGATES (per cu. yd.).

Washed sand: 26*s.* 9*d.* Graded gravel (¾ in.): 24*s.* 3*d.* Pit ballast: 25*s.* 6*d.*

CEMENT (per ton).

Ordinary Portland.—6 tons and upwards: 115*s.* 3*d.*; 1 ton to 6 tons: 127*s.* 3*d.*

Rapid-hardening Portland: As ordinary Portland plus 10*s.* 6*d.* "Aquacrete" and "417": As ordinary Portland plus 32*s.* 6*d.* "Colorcrete" (buff, red, and khaki): As ordinary Portland plus 60*s.* "Snowcrete" (white): 280*s.* 9*d.*

"Super-Cement": As ordinary Portland plus 32*s.* 6*d.*

High-alumina cement.—6 tons: 314*s.* 6*d.*

"Super Snowcem" waterproof cement paint: 100*s.* per cwt.

REINFORCEMENT (per ton ex stock including delivery in quantities from 10 to 500 tons).

Plain mild steel rods per B.S. No. 785.—1 in. and over: £50 5*s.*; ⅞ in. and ¾ in.: £51; ⅝ in.: £51 15*s.*; ½ in.: £53 7*s.* 6*d.*; ⅜ in.: £54 17*s.* 6*d.*; ¼ in.: £58 17*s.* 6*d.*

Hot-rolled deformed bars: As plain bars plus £1.

High-tensile (minimum yield point 44,000 lb. per sq. in.): As mild steel plus 19*s.*

(For basic prices and allowances for quantities exceeding 500 tons and extras for quantities less than 10 tons, lengths greater than 40 ft. or less than 5 ft., bundling, labelling, and delivery in other areas, see "Concrete Year Book, 1961".)

Fabric per B.S. 1221A (per sq. yd.).—No. 109: 3*s.* ¼*d.*; No. 121: 5*s.* 7½*d.*; No. 124: 3*s.* 4½*d.*; No. 125: 2*s.* 10*d.*; No. 126: 2*s.* 6¼*d.*

TIMBER.—Sawn deal shutter boards: £95 to £100 per standard (165 cu. ft.); 1-in. boards: 1*s.* (av.) per sq. ft.; 1¼-in. boards: 1*s.* 3½*d.* (av.) per sq. ft.

MATERIALS AND LABOUR.

Based on net cost of materials plus 10 per cent. and net cost of labour plus 45 per cent. for insurances, etc. (10 per cent.), on-costs (22 per cent.) and profit (10 per cent. on gross cost = 13 per cent. on net cost). No allowance for non-productive ordinary time, overtime, travelling time, fares, subsistence, etc. Wages (per hour).—Carpenters and joiners: 5*s.* 1½*d.*; labourers: 4*s.* 6*d.*; mixer and hoist operators: 5*s.*; bar benders: 4*s.* 11½*d.*

PORTLAND CEMENT CONCRETE (1 : 2 : 4).

Foundations (per cu. ft.).—3*s.* 6*d.*

Suspended slabs (per sq. yd.).—6 in., 18*s.* 3*d.*; 7 in., 21*s.* 4*d.*; 9 in., 27*s.* 3*d.*

Beams (per cu. ft.).—4*s.* 1*d.* Columns (per cu. ft.).—4*s.* 7*d.*

Walls (per sq. yd.).—6 in., 19*s.* 11*d.*; 9 in., 29*s.* 10*d.*;
12 in. and over (per cu. ft.), 3*s.* 7*d.*

Extra (per cu. yd.) for rapid-hardening Portland cement. 1 : 2 : 4.—2*s.* 8*d.*

REINFORCEMENT.—Mild steel rods cut, bent and fixed (per cwt.).

	In floor slabs and beams.	In columns.	In walls.	Stirrups, binders, etc.
1 in. and over	75*s.* 6*d.*	81*s.* 2*d.*	78*s.* 10*d.*	—
⅞ in. and ¾ in.	76*s.* 3*d.*	81*s.* 11*d.*	79*s.* 7*d.*	—
⅝ in.	77*s.* 1*d.*	82*s.* 9*d.*	80*s.* 5*d.*	—
½ in.	84*s.* 7*d.*	91*s.* 5*d.*	89*s.* 2*d.*	—
⅜ in.	86*s.* 3*d.*	93*s.* 1*d.*	90*s.* 10*d.*	103*s.* 4*d.*
$\frac{5}{16}$ in.	88*s.* 6*d.*	95*s.* 3*d.*	93*s.* 0*d.*	105*s.* 6*d.*
¼ in.	89*s.* 7*d.*	96*s.* 4*d.*	94*s.* 1*d.*	106*s.* 7*d.*

Fabric per B.S. No. 1221A in flat areas (per sq. yd.) including straight cutting.—No. 109: 4*s.* 5*d.*; No. 121: 8*s.*; No. 124: 4*s.* 9½*d.*; No. 125: 4*s.* 2½*d.*; No. 126: 3*s.* 7½*d.*

SHUTTERING (FORMWORK).—Assuming five uses of wooden shutters for floor soffits and walls, and three uses for beams.

Soffits of floors, flat roofs, etc. (per sq. yd.): 16*s.* 3*d.*; ditto sloping: 18*s.* 1*d.*

Walls and partitions (per sq. yd.): 19*s.* 11*d.*; ditto curved: 26*s.* 10*d.*

Rectangular beams, lintels, columns, etc. (per sq. ft.): 2*s.* 8*d.*; ditto circular: 3*s.* 8*d.*

MISCELLANEOUS ADVERTISEMENTS.

Situations Wanted, 5d. a word: minimum, 12s. Situations Vacant, 6d. a word: minimum, 15s. Other miscellaneous advertisements, 6d. a word: minimum, 15s. Displayed advertisements, 40s. per column inch. Box number 1s. extra.

Advertisements for the August number must reach this office, 14 Dartmouth Street, London, S.W.1, by July 11.

SITUATIONS VACANT.

SITUATIONS VACANT. Concrete laboratory technicians with good experience are required for our central laboratories in London. Apply, with full details, to MESSRS. SANDBERG, 40 Grosvenor Gardens, London, S.W.1. Starting salaries up to £750 per annum.

SITUATIONS VACANT. Consulting engineers require senior and assistant engineers experienced in design, detailing and construction of reinforced concrete structures. Excellent opportunities in expanding practice with first-class conditions of employment, pension, etc. Apply in writing, with full details, to JOHN BUNCE & ASSOCIATES, 28 St. George's Road, London, S.W.19.

SITUATION VACANT. Qualified engineer-designer required, experienced in reinforced concrete, preparing schemes, visiting sites, etc. Must have degree and/or professional qualifications. Good salary, and superannuation scheme after probationary period. Applications, stating age, education, qualifications and experience, to A. MONK & CO. LTD., 2 Exchange Place, Middlesbrough.

SITUATIONS VACANT. Harrow reinforced concrete engineers and contractors require experienced detailing-draughtsmen. Five-days' week; interesting work; modern offices; pension scheme after qualifying period. Write BIERRUMS, 167–173 Imperial Drive, Harrow, or telephone for appointment Field End 7701.

SITUATIONS VACANT. Reinforced Concrete Designers, Detailers and Draughtsmen required at Glasgow, Newhouse, Edinburgh, Gateshead, Manchester and Altrincham. Progressive positions with established company. Five-days' week. Non-contributory pension scheme and profit-sharing bonus. Apply to the Divisional Engineer at any of the Branch Offices or to the Regional Engineer, THE SQUARE GRIP REINFORCEMENT CO., LTD., Market Street, Altrincham, Cheshire.

SITUATIONS VACANT. CLARKE, NICHOLLS & MARCEL require experienced reinforced concrete designer-detailers and draughtsmen for their Bristol and Cardiff offices. Positions are pensionable, and offer first-class experience for those studying for professional qualifications. A senior structural engineer is also required for the Cardiff office, and preference would be given to an A.M.I.Struct.E. Apply to 10 Apsley Road, Bristol 8, or South Wales Institute of Engineers Building, Park Place, Cardiff.

SITUATIONS VACANT. Reinforced concrete and structural steelwork designers and detailers required at Bristol head office and in the London office. Permanent positions covering most fields of reinforced concrete and steelwork design. Pension and insurance schemes. Attractive salaries. Full details to NORRIS CONSULTANTS LTD., Beacon House, Queen's Road, Clifton, Bristol, 8.

SITUATIONS VACANT. Consulting engineers have vacancies for the following: Reinforced concrete designers with A.M.I.Struct.E.; Designer-detailers with H.N.C. or similar; Detailers with minimum two years' experience. The positions are permanent, with opportunity for advancement. Modern office and pleasant conditions. Salaries in accordance with experience. Apply BYLANDER, WADDELL & PARTNERS, 160 Wembley Park Drive, Wembley, or 10 Carver Street, Sheffield.

SITUATIONS VACANT. A few experienced reinforced concrete designer-detailers required for interesting and progressive posts with consulting engineers at their offices in Cannon Street, London, E.C.4. Salary range £850–£1500. Luncheon vouchers. Pension scheme. Apply EDWARD A. PITCHER & PARTNERS, 58–60 Cannon Street, London, E.C.4. Telephone: City 2292.

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SITUATIONS VACANT. Detailers experienced in reinforced concrete required for London professional office. The work is varied, comprising all types of construction in concrete and steel, and offers scope for anyone interested in gaining design experience. Permanent position with excellent prospects. Five-days' week. Apply, stating full experience, to FARMER & DARK, Romney House, Tufton Street, London, S.W.1.

SITUATIONS VACANT. Reinforced concrete engineers require experienced section-leaders and detail/draughtsmen. Interesting work, five-days' week, luncheon vouchers, own pension scheme, etc. Salaries in accordance with experience. Apply in writing to THE REINFORCED CONCRETE STEEL CO. LTD., 54 Victoria Street, Westminster, S.W.1.

SITUATIONS VACANT. Reinforced concrete designer-detailers and detailers required by LEONARD & GRANT in their South London and Edinburgh offices. Applicants should have three years' minimum experience in position applied for. Good salaries and prospects, luncheon vouchers, etc. Interview by appointment. Telephone: London, MACaulay 6477; Edinburgh, CAL 3807.

SITUATION VACANT. Representative. Opportunity for enthusiastic young man to obtain position on sales technical staff of company with renowned product indispensable to reinforced concrete construction. Initially mobile over 50-miles radius of South Coast—London. Knowledge of reinforced concrete, and holding a driving licence advantageous. Applicants must be of pleasant personality, keen, energetic, conscientious, adaptable, and should have been educated to the standard of G.C.E. Written applications, treated in strict confidence, with full particulars, details of qualifications, etc., to Box 4754, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

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SITUATION VACANT. Section leader to supervise section designing reinforced concrete structures. University graduate (British) preferred, conversant with London Buildings Bye-laws and accustomed to discussions with architects. Frequent visits to sites. Salary subject to discussion. Write Chief Engineer, Trollope & Colls Ltd., 1 Noble Street, Gresham Street, London, E.C.2.

SITUATION VACANT. Major mining concern in West Africa wishes to employ a Clerk of Works, to be in charge of all building and construction work on the property. Experience in reinforced concrete work on the surface and underground is essential. The Clerk of Works will also be responsible for the Sawmill and Carpenter's Shop. The starting salary will be not less than £140 per month and accommodation and passages are provided free for the applicant and his wife. Tours are of 15 months followed by 3 months' leave. The appointment is permanent and pensionable. The climate is healthy and suitable for children. Write, with full particulars and qualifications, experience and age, to Box 4768, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Designer-detailers with minimum of three years' experience in reinforced concrete required in our London and Guildford offices. Salary according to qualifications and experience. Pension scheme. Write or telephone for appointment, either Balham 2486 or Guildford 2483. Terecon Industrial Design Engineers, 11a Station Parade, Balham High Road, London, S.W.12.

SITUATION VACANT. Representative with proved ability and connections, particularly with architects and municipal authorities, etc., required by prominent designers, suppliers and sub-contractors to the building and civil engineering industries for north-east, east and south-east London and adjoining Home Counties. Superannuated staff appointment with salary, commission, expenses and car provided. Write, giving full details of experience, salary required, age, etc., to The Secretary, The Rom River Co. Ltd., 100 Stewarts Road, London, S.W.8.

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invite applications from reinforced concrete designers who are at present earning £1100–£1400 per annum and are prepared to accept responsibility. Write or telephone for application form from 54 South Side, Clapham Common, London, S.W.4. (MACaulay 5522.)

SITUATION VACANT. Deputy to chief engineer required for leading structural consultants, London head office. Commencing salary £3,000 per annum rising by annual increments of £200 per annum to £4,000 per annum and subject to merit thereafter. Applicants must be chartered structural engineers and of exceptional technical and administrative ability, between the age of 35 and 45 with at least 5 years' experience in position of full personal responsibility for the preparation of calculations, projects and detailed designs for large reinforced concrete work. Pension scheme available. Applications, which will be treated in the strictest confidence, to Box 4770, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Designer of shuttering and builders' plant required by manufacturer. Concrete mould experience advantageous. Full details of experience and qualifications to Chief Engineer, A.B. Mould & Construction Co., Ltd., Vulcan Works, New Addington, Croydon.

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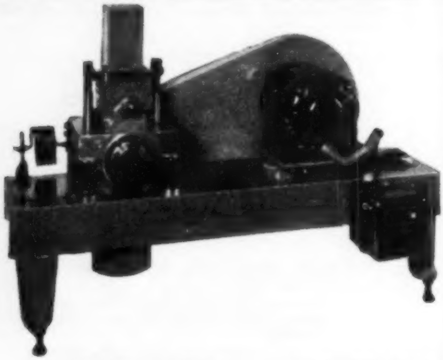

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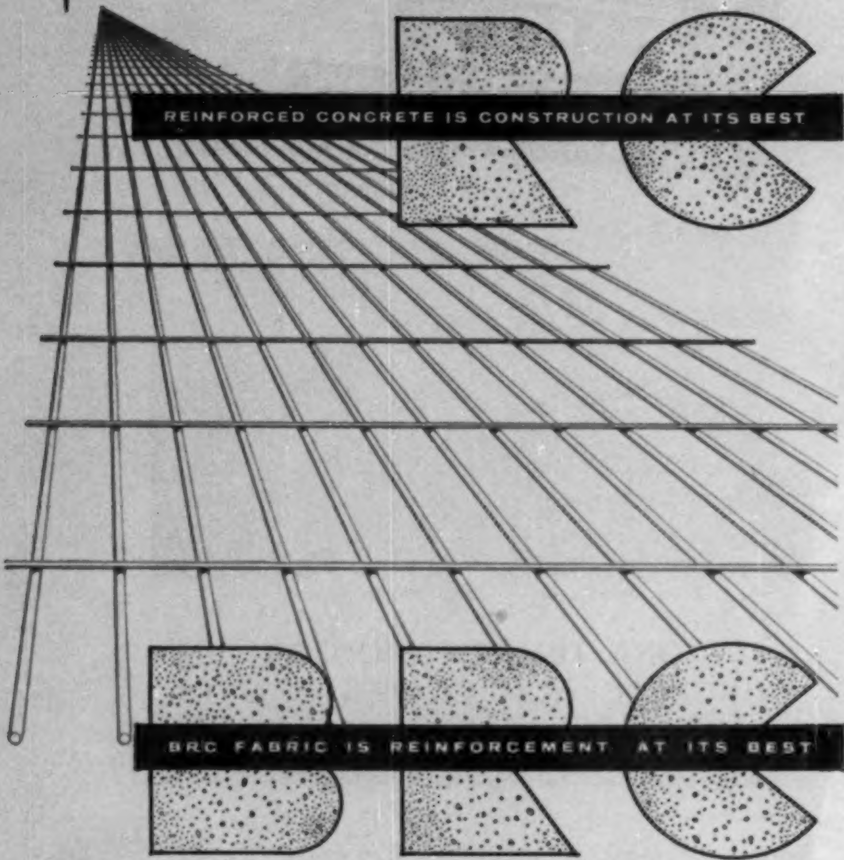

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